Radiological Health Data and Reports

VOLUME 8, NUMBER 5
MAY 1967
(Pages 245-300)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 5, May 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

REPORTS

Page

Radiation Hazards from X-ray Diffraction Equipment 245
J. R. Howley and *C. Robbins*

DATA

SECTION I. MILK AND FOOD 251

National and International Milk Surveillance 251

1. Pasteurized Milk Network, January 1967, *PHS* 252
2. Canadian Milk Network, January 1967 258
3. Pan American Milk Sampling Program, January 1967, *PAHO* and *PHS* 259

State Milk Surveillance Activities 260

1. Connecticut Milk Network, October–December 1966 261
2. Indiana Milk Network, October–December 1966 262
3. Michigan Milk Network, October–December 1966 263
4. Minnesota Milk Network, October–December 1966 265
5. New York Milk Network, October–December 1966 267
6. Pennsylvania Milk Network, October–December 1966 269

Food and Diet Surveillance Activities 271

1. Estimated Daily Intake of Radionuclides in California Diets, May–August 1966 271

CONTENTS—continued

	Page
2. Estimated Daily Intake of Radionuclides in Connecticut Standard Diet, July–December 1966	274
SECTION II. WATER	277
Gross Radioactivity in Surface Waters of the United States November 1966	278
SECTION III. AIR AND DEPOSITION	281
1. Radiation Surveillance Network, January 1967, *PHS*	282
2. Canadian Air and Precipitation Monitoring Program, January 1967	285
3. Mexican Air Monitoring Program, January 1967	287
4. Pan American Air Sampling Program, January 1967 *PAHO* and *PHS*	287
5. Plutonium in Airborne Particulates, October–December 1966, *PHS*	288
SECTION IV. OTHER DATA	290
Radionuclides in Alaskan Caribou and Reindeer, October–November 1966, *PHS*	290
Environmental Levels of Radioactivity at Atomic Energy Commission Installations	292
1. Mound Laboratory, January–June 1966	292
2. Rocky Flats Plant, July–December and Annual Summary 1966	294
SECTION V. TECHNICAL NOTES	296
Radiological Monitoring of the Native Texas Commercial Oyster *J. J. Stanko* and *M. C. Wukasch*	296
Strontium-90, Cesium-137, and Polonium-210 in Human Tissues *E. J. Baratta* and *E. S. Ferri*	298
Reported Nuclear Detonations, April 1967	299
Synopses	iii
Symbols, Units, and Equivalents	Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
National Center for Radiological Health
Donald L. Snow, Chief

BOARD OF EDITORIAL ADVISORS

Dr. Hugh B. Mitchell
Department of Defense
Dr. Ronald G. Menzel
Department of Agriculture
Dr. Wilfrid B. Mann
Department of Commerce
Robert E. Simpson
Food & Drug Administration, DHEW
John A. Harris
Atomic Energy Commission

STAFF

Managing Editor
Samuel Wieder
Assistant Managing Editor
Charles F. Coyle
Senior Technical Editor
Marvin Rosenstein
Technical Editors
Kurt L. Feldmann
Richard Wromble
Illustrator
Marylee Hill

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Maryland 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

Reports

Radiation Hazards from X-ray Diffraction Equipment

J. R. Howley and *C. Robbins*[1]

Improper or careless use of X-ray diffraction equipment can cause severe burns to the upper extremities of the body of the operator. These burns are slow to heal and can lead to cancer. Cataracts and other opacities can be produced in the eye with a single exposure of 200 roentgens. The use of inadequate survey equipment can lead to a gross underestimate of the hazard. Since serious injury from intense primary beam radiation can occur in a matter of seconds and the hazard from scattered radiation is also significant, the use of film badge monitoring alone can give a false sense of protection. Recommendations are given.

X-ray diffraction has become a powerful industrial and medical research tool for the study of solids and liquids. Every day thousands of X-ray diffraction patterns are made for the analysis of practically every conceivable material known to man.

Although much has been reported on technical accomplishments with the use of this equipment, relatively little has been said concerning its hazards. Most of the texts on X-ray crystallography make no mention of the very high exposure rates ranging up to one million roentgens per minute from the primary beam of an X-ray diffraction unit. In the hands of a careless or uninformed person, this unit becomes a very dangerous instrument.

The most frequently reported injury from this equipment is severe burns to the upper extremities of the body (*1–6*). These burns are slow to heal and can lead to cancer. Injuries usually result from carelessness or a failure to fully appreciate the hazards involved.

A second type of injury to be expected is the formation of very small cataracts and other opacities in the lens of the eye (*7–10*). This injury is difficult to relate to cause since the cataracts or opacities may be delayed as much as 5 years after exposure. An occasional report of this type of injury among crystallographers should not come as a surprise, after a consideration of the following epidemiological observations.

Desjardins (*7*) in 1931 noted the sensitivity of the adult lens of the eye to X radiation. Colwell (*8*) in 1934 concluded that there is a danger of opacity in the lens when an eye has received a full erythema dose, irrespective of the quality of the radiation. Quimby's data (*11*) in 1952 showed how the threshold exposure for erythema decreases with the energy of the radiation. Merriam and Focht (*9*) in 1957 studied the incidence of cataracts as a side effect of therapeutic radiation, and reported a minimum cataractogenic exposure of 200 roentgens for single-treatment therapy. For extended treatments from 3 weeks to 3 months, they report a minimum nearer 400 R (figure 1).

[1] Mr. Howley and Mr. Robbins are health physicists, Radiation Safety Section, Department of Nuclear Medicine, National Institutes of Health, Bethesda, Md. 20014.

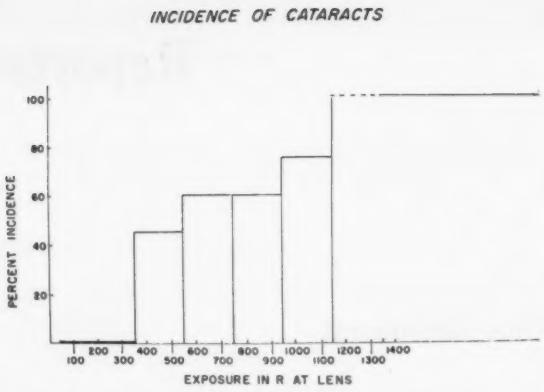

Figure 1. Percentage incidence of cataracts of the eye at varying x-ray exposures

The problem

The radiation hazards around X-ray diffraction equipment vary with the type of operation and the vintage of the equipment. One very common arrangement is an X-ray tube enclosed in a protective housing which has four ports, each port having a manually operated cover (figure 2). If the unit is energized and these covers are lifted, X rays escape. Without the protective interlocks and shutters of the more recently designed units (*12–16*), the unwary can manipulate the beam stopper and the X-ray diffraction camera while exposed to radiation. This procedure is done to avoid interrupting an exposure to cameras set up on the other ports. This operation is not recommended but occurs more often than users care to admit. X-ray films exposed near the unit show a varied pattern of scattered radiation near the X-ray tube port and powder camera. This presents a problem in selecting monitoring equipment for such heterogeneous scattered radiation, since ion chambers must be fully covered by a uniform radiation field for proper operation.

Method

McLaughlin and Blatz (*15*) reported using detectors readily available to the health physicist, in their studies of X-ray diffraction radiation hazards. They felt correction factors as high as 2 might be necessary for their data, based on Day's study of soft X-ray measurements with thimble chamber r-meters.

T. H. Rogers (*17*) and other investigators (*18–20*), in discussing the measurements of high-intensity radiation from beryllium window X-ray tubes, have drawn attention to the necessity for extremely thin-walled chambers in r-meters, in order to obtain results comparable to a standard free-air chamber.

The present study compares several types of radiation detectors (table 1) for the measurement of incident and scattered X rays, with considerable variation in results. Small thermoluminescent rod and disc dosimeters, calibrated in the incident beam with thin end-window r-meters, gave better results. The end-window r-meters (2,500 R and 250 R) were found the most satisfactory of the instruments to work with because of the small size, window thickness, and ease of handling. These r-meters are factory calibrated with free-air chambers for energies below 35 keV.

Table 1. Dose rate measurements with various meters

Distance (cm)	Angle (°)	R-meter Victoreen thin end-window Model 651–2 (mR/hr)	Victoreen Model 440		Cutie Pie Tracerlab Model SUIH	
			(mR/hr)	(Percent of r-meter)	(mR/hr)	(Percent of r-meter)
40	45	375	250	67	89	24
60	90	600	150	25	45	8
60	120	3,900	220	5.6	400	10

Large sheets of calibrated X-ray film placed about the diffraction unit added considerably to a thorough evaluation of the scattered radiation. Dental size dosimeter film exhibited a flatter calibration curve and would be preferable, particularly if it could be obtained in large sheets.

Findings

The intensity of the incident X-ray beam, known to be large, was measured in the following manner: a 2,500-roentgen thin end-window chamber was located at various positions along the axis of the incident X-ray beam and the exposure rates recorded. The data obtained by this experiment were plotted (figure 3). A linear extrapolation leads to a value of 400,000 R/min at the X-ray tube port. This exposure rate is typical for a unit operating at 50 kilo-

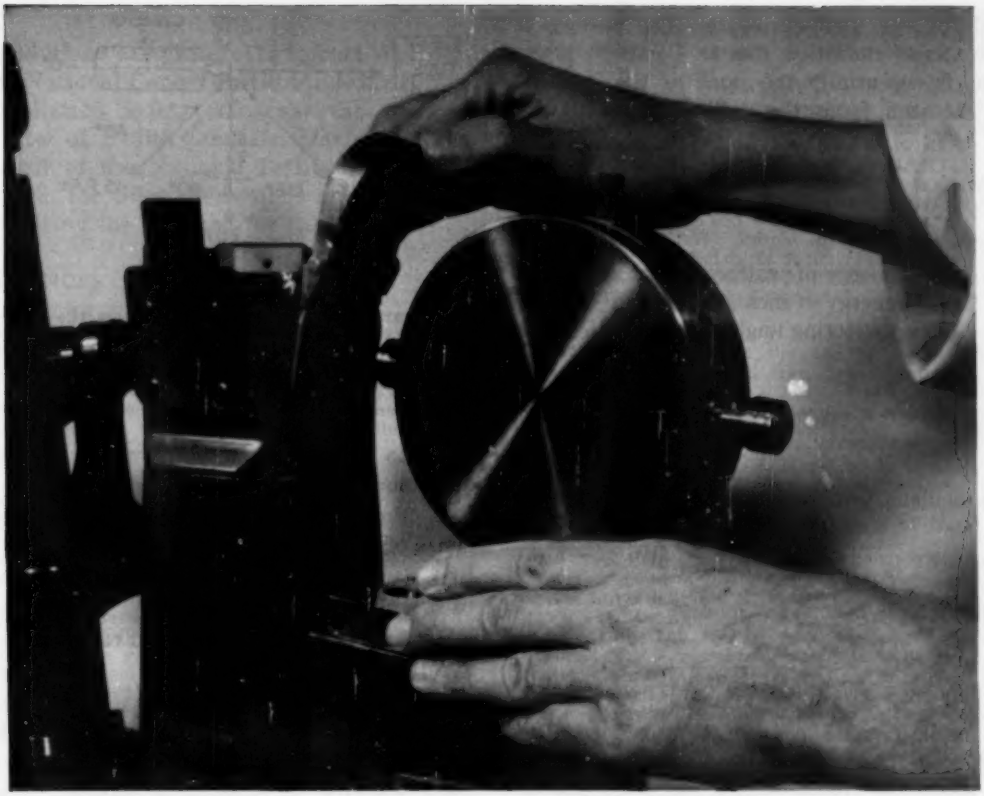

Figure 2. X-ray diffraction tube port and camera

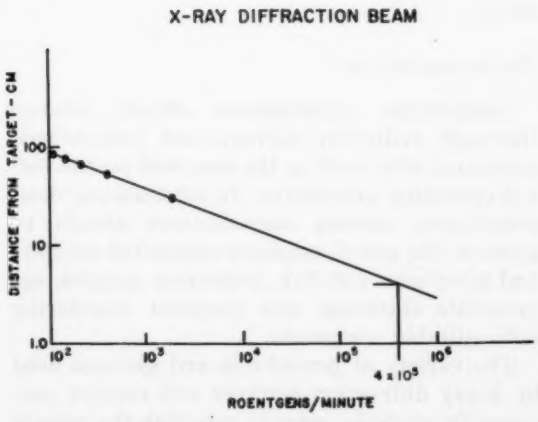

Figure 3. Results of incident beam measurement

volts, 20 millamperes, and with minimum inherent filter of approximately 1 millimeter of beryllium. This agrees substantially with values reported by others (*17, 20*). The half-value layer of the beam was 0.05-mm aluminum corresponding to an equivalent energy of 8 keV. The addition of a 0.0007-inch (0.0175 mm) nickel filter, commonly used in X-ray diffraction, reduced the extrapolated value of the exposure in the incident beam at the X-ray tube port to 200,000 R/min.

The energy of the scattered radiation was taken to be equal to the energy of the incident beam, since the measured half-value layer of 90° scattered radiation was 0.05 mm of aluminum, corresponding to the same energy ob-

tained for the incident beam. The energy of the scattered radiation due to Compton interactions is essentially the same as the incident beam as seen from the following calculation for 8 keV:

$$E' = \frac{E}{1+\alpha(1-\cos\phi)} \qquad (1)$$

where E' = energy of scattered beam,
E = energy of incident beam,
ϕ = scattering angle,
$\alpha = \frac{E}{M_0 c^2}$
M_0 = rest mass of an electron,
and c = velocity of light.

For an incident X-ray beam with an 8 keV energy:

$$\alpha = \frac{E}{M_0 c^2} = \frac{0.008 \text{ MeV}}{0.511 \text{ MeV}} = 0.016$$

and equation (1) becomes,

$$E' = \frac{E}{1+0.016\ (1-\cos\phi)}.$$

Since the half-value layer of the scattered radiation was found to be the same as the incident beam, the characteristic radiation due to photoelectric interactions is either equivalent to 8 keV, insignificant, or not measured. For these reasons we felt justified in using the incident beam to calibrate film and other radiation detectors to be used for monitoring scattered radiation.

The manipulation shown in figure 2 for an unfiltered beam resulted in an exposure rate from scattered radiation of 2.0 R/hr to the fingers of the left hand, 50 R/hr to the fingers of the right hand, and 150 mR/hr to the head. The radiation field around the camera is unsymmetrical. When the camera is 10 cm from the X-ray tube port, the exposure rate at 10 cm from the face of the camera varies from 15 R/hr at 45° to 25 R/hr at 90°, and 150 R/hr at 135° from the direction of the primary X-ray beam (figure 4).

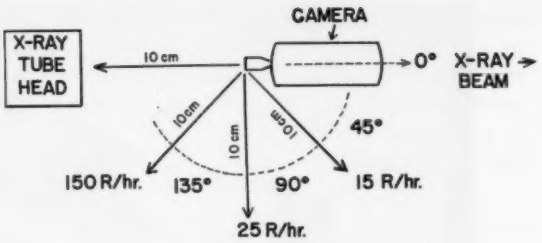

Figure 4. Scattered radiation from the camera

Conclusions

From a study of the X-ray diffraction equipment, the intensity of the X-ray beam, and the hazards involved, the following conclusions were made:

a. film badges give the individual a false sense of protection;

b. serious injury can occur within a matter of seconds; and

c. the hazard from scattered radiation can be significant.

Film badges are most useful where the radiation is diffuse and the intensity of radiation is low enough so that a monthly reporting is sufficient warning of impending danger. The intensity of X-ray diffraction exposures can be such that permanent damage will be done before the worker is even aware of his danger. Burns from scattered radiation reported in the literature were due to intensities similar to the ones observed around the units used in this study.

Recommendations

Responsible investigators should conduct thorough radiation surveys and indoctrinate personnel who work in the area and post standard operating procedures. In establishing these procedures, serious consideration should be given to the use of remotely controlled shutters and interlocks (*12–14*), protective goggles, appropriate shielding, and frequent monitoring with suitable equipment.

The variety of procedures and systems used by X-ray diffraction workers will require considerable study in order to establish the special protection requirements for each installation.

Acknowledgements

The authors are grateful to Robert W. Swain of the National Cancer Institute; J. M. Brown, Jr., radiation safety officer at the National Institutes of Health; and Dr. Marie U. Nylen and staff of the National Institute of Dental Research, for their suggestions and assistance in gathering the material for this paper.

REFERENCES

(*1*) BURDICK, K. G. Radiodermatitis due to exposure in industry. JAMA 188:607-608 (May 1964).
(*2*) BAIN, J. T. B. X-ray burns in industry. British Med J 1:1476-1477 (May 1962).
(*3*) COMMISSION ON CRYSTALLOGRAPHIC APPARATUS. Radiation hazards associated with x-ray diffraction techniques. Acta Crystallographica (Denmark) 16:324-328 (April 10, 1963).
(*4*) WATROUS, R. M., H. W. HODGES, and M. J. McANDREW. Radiation burns from diffraction apparatus simulating infections. JAMA 152:513 (1953).
(*5*) McBRIDE, W. W. Radiodermatitis from diffraction apparatus. Arch Environ Health 4:191–195 (February 1962).
(*6*) ARCHER, V. E. Report of x-ray diffraction burn at NIH. National Institutes of Health, Radiation Safety File, Bethesda, Md. 20014 (1955).
(*7*) DESJARDINS, A. U. Action of roentgen rays and radium on the gastro-intestinal tract; experimental data and clinical radiotherapy. Amer J Roentgenol 26:151-190 (1931).
(*8*) COLWELL, H. A. X-ray and Radium Injuries. Oxford University Press (1934), p. 148.
(*9*) MERRIAM, G. R., and E. F. FOCHT. Clinical study of radiation cataracts and the relationship to dose. Amer J Roentgenol Rad Ther Nucl Med 77:759-785 (May 1957).
(*10*) HAYE, C., H. JAMMEL, and M. A. DOLFUS. L'Oeil et les Radiations Ionisantes, Vol. 1 (1965).
(*11*) QUIMBY, E. H. Physical Foundations of Radiology, 2nd Edition, Hoeber, New York, N.Y. (1952).
(*12*) KENNARD, O., and A. J. P. MARTIN. Labyrinth radiation trap for use with standard x-ray diffraction equipment. J Sci Instr 36:48 (January 1959).
(*13*) HUGHES, W. Simple shutter-closing device for x-ray tubes. J Sci Instr 39:93 (1962).
(*14*) BARNES, D. C., and A. FRANKS. Safety shutter for crystallographic x-ray tubes. J Sci Instr 39:648 (1962).
(*15*) McLAUGHLIN, J. E., and H. BLATZ. Potential radiation hazards in the use of x-ray diffraction equipment. Amer Ind Hyg Assoc Quart 16:108-112 (June 1955).
(*16*) DAY, FRANK H. Thimble chamber calibration on soft x-rays. J Res Nat Bur Std 41:399 RP 1926 (October 1948).
(*17*) ROGERS, T. H. (Machlett Laboratory, Inc.). High intensity radiation from beryllium window x-ray tubes. Read before the Thirty-Second Annual Meeting of the Radiological Society of North America, Chicago, Ill. (December 1-6, 1946).
(*18*) TAYLOR, L. S., and C. F. STONEBURNER. The measurement of low voltage X-ray intensities. J Res Nat Bur Std 9:769-780 (1932).
(*19*) VICTOREEN, J., E. D. TROUT, and Z. J. ATLEE. The behavior of thimble chambers when used for the measurement of very soft radiation. Amer J Roentgenol 53:391-394 (1945).
(*20*) QUIMBY, E. H., and E. F. FOCHT. Dosage measurements in contact roentgen therapy. Amer J Roentgenol 50:653-658 (1943).

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. The total diet is the most direct measure of intake of radionuclides; however, because specific dietary data are not readily available, indicator foods may be used to estimate radionuclide intake.

Fresh milk is consumed by a large segment of the U.S. population. It contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, and is the major source of dietary intake of short-lived radionuclides. For these reasons, it is the single food item most often used as an indicator of the population's intake of radionuclides. In the absence of specific dietary information, one may assume that the total daily dietary intake of selected radionuclides is equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analysis of the total diet or representative principal food items or groups, combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5–6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N. Y. (1959).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the Internationl Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N. Y. (1965).

National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk.

1. Pasteurized Milk Network January 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN), was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (*1*).

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The results for January 1967 and the fourth quarter of 1966 are presented in table 2. Barium–140 concentrations for all stations were below the limits of detectability. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the mini-

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error * (pCi/liter)	Concentration (pCi/liter)	Error * (percent of concentration)
Iodine-131	Less than 100	10	100 or greater	10
Barium-140	Less than 100	10	100 or greater	10
Cesium-137	Less than 100	10	100 or greater	10
Strontium-89	Less than 50	5	50 or greater	10
Strontium-90	Less than 20	2	20 or greater	10

* Two standard deviations.

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentration of radionuclides in pasteurized milk for fourth quarter 1966 and January 1967

Sampling location		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)	
		Fourth quarter 1966	Jan 1967	Fourth quarter 1966	Jan 1967	Fourth quarter 1966	Jan 1967	Fourth quarter 1966	Jan 1967
Ala:	Montgomery	< 5	< 5	10	11	0	30	15	20
Alaska:	Palmer	< 5	< 5	14	11	0	0	25	20
Ariz:	Phoenix	< 5	< 5	3	2	0	0	5	10
Ark:	Little Rock	5	< 5	24	24	0	0	20	20
Calif:	Sacramento	< 5	< 5	3	2	0	20	5	10
	San Francisco	< 5	< 5	3	6	0	0	10	< 5
C.Z.:	Cristobal	< 5	< 5	5	7	0	0	25	35
Colo:	Denver	< 5	< 5	8	6	0	0	10	5
Conn:	Hartford	< 5	NA	10	10	0	0	20	20
Del:	Wilmington	< 5	NA	12	11	0	10	20	20
D.C.:	Washington	< 5	< 5	12	12	0	0	15	15
Fla:	Tampa	10	< 5	10	10	0	10	95	70
Ga:	Atlanta	5	< 5	16	18	0	30	25	25
Hawaii:	Honolulu	< 5	< 5	4	3	0	0	15	15
Idaho:	Idaho Falls	< 5	< 5	9	6	0	0	15	10
Ill:	Chicago	< 5	< 5	8	8	0	0	15	20
Ind:	Indianapolis	< 5	< 5	10	9	0	0	15	20
Iowa:	Des Moines	< 5	< 5	9	8	0	0	15	15
Kans:	Wichita	< 5	< 5	14	9	0	0	10	10
Ky:	Louisville	10	< 5	13	15	0	0	10	15
La:	New Orleans	< 5	< 5	27	25	0	0	35	35
Maine:	Portland	< 5	< 5	14	13	0	0	45	45
Md:	Baltimore	< 5	< 5	11	12	0	0	15	20
Mass:	Boston	< 5	< 5	13	13	0	0	35	40
Mich:	Detroit	< 5	NA	10	9	0	10	15	20
	Grand Rapids	< 5	< 5	12	11	0	0	20	20
Minn:	Minneapolis	< 5	< 5	21	14	0	0	15	15
Miss:	Jackson	15	< 5	17	23	0	30	15	20
Mo:	Kansas City	< 5	< 5	11	9	0	10	10	10
	St. Louis	< 5	< 5	12	11	0	0	15	15
Mont:	Helena	< 5	< 5	12	8	0	0	20	15
Nebr:	Omaha	< 5	< 5	10	11	0	0	10	10
Nev:	Las Vegas	< 5	< 5	3	3	0	0	10	10
N.H:	Manchester	< 5	< 5	15	16	0	0	45	45
N.J:	Trenton	< 5	< 5	10	10	0	0	20	25
N. Mex:	Albuquerque	< 5	< 5	4	5	0	0	5	5
N.Y:	Buffalo	< 5	< 5	9	10	0	0	20	25
	New York	< 5	< 5	12	12	0	0	25	20
	Syracuse	< 5	< 5	9	9	0	10	20	25
N.C:	Charlotte	< 5	< 5	20	19	0	0	20	20
N. Dak:	Minot	< 5	< 5	24	16	0	0	20	15
Ohio:	Cincinnati	< 5	< 5	10	10	0	0	15	15
	Cleveland	< 5	< 5	10	12	0	0	20	20
Okla:	Oklahoma City	< 5	< 5	9	11	0	10	10	10
Ore:	Portland	< 5	10	10	8	0	20	20	20
Penn:	Philadelphia	< 5	< 5	11	12	0	0	20	20
	Pittsburgh	< 5	NA	14	12	0	0	20	25
P.R.:	San Juan	5	5	6	4	0	0	15	20
R.I:	Providence	< 5	< 5	12	12	0	0	25	25
S.C:	Charleston	< 5	< 5	20	19	0	60	30	30
S. Dak:	Rapid City	< 5	< 5	16	11	0	0	15	25
Tenn:	Chattanooga	< 5	< 5	18	18	0	10	20	20
	Memphis	< 5	< 5	14	13	0	0	10	10
Tex:	Austin	< 5	< 5	4	5	0	40	5	10
	Dallas	< 5	< 5	10	8	0	30	10	10
Utah:	Salt Lake City	< 5	10	12	7	0	0	15	10
Vt:	Burlington	< 5	< 5	11	12	0	0	25	25
Va:	Norfolk	10	< 5	14	13	0	0	15	15
Wash:	Seattle	< 5	< 5	16	8	0	0	35	25
	Spokane	< 5	< 5	14	13	0	0	25	25
W. Va:	Charleston	5	< 5	15	14	0	0	10	15
Wisc:	Milwaukee	< 5	NA	9	9	0	0	15	20
Wyo:	Laramie	< 5	< 5	8	11	0	0	10	20
Network average		< 5	< 5	11.7	10.9	0	5	20	20

NA, no analysis.

Table 3. Iodine-131 concentrations, pCi/liter, in

Station location		January 1967														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ala:	Montgomery					< 10						114	72	73		
Alaska:	Palmer					< 10						< 10				
Ariz:	Phoenix						<10						<10			
Ark:	Little Rock			<10						21				23		
Calif:	Sacramento						22									
	San Francisco					15							21			
C.Z:	Cristobal			<10						<10						
Colo:	Denver					<10							<10			
Conn:	Hartford						<10							<10		
Del:	Wilmington					<10								<10		
D.C:	Washington						<10						<10			
Fla:	Tampa						<10							18		
Ga:	Atlanta				<10							113				
Hawaii:	Honolulu			<10							11					
Idaho:	Idaho Falls			<10						<10						
Ill:	Chicago			<10							17					
Ind:	Indianapolis			<10						<10						
Iowa:	Des Moines					11							<10			
Kans:	Wichita		<10							<10						
Ky:	Louisville			<10							20					
La:	New Orleans					<10							<10			
Maine:	Portland					<10						< 10				
Md:	Baltimore			<10								< 10				
Mass:	Boston			<10							<10					
Mich:	Detroit			18							10					
	Grand Rapids			<10						<10						
Minn:	Minneapolis			<10							<10					
Miss:	Jackson									36						
Mo:	Kansas City						11							32		
	St. Louis						<10							<10		
Mont:	Helena			<10							<10					
Nebr:	Omaha						<10						19			
Nev:	Las Vegas					<10							<10			
N.H:	Manchester			<10							<10					
N.J:	Trenton			<10							<10					
N. Mex:	Albuquerque			<10						<10						
N.Y:	Buffalo						<10							<10		
	New York			<10						<10						
	Syracuse				<10							19				
N.C:	Charlotte			<10						15						
N. Dak:	Minot			<10						<10						
Ohio:	Cincinnati			<10							<10					
	Cleveland						<10							<10		
Okla:	Oklahoma City				<10					23						
Ore:	Portland						74							17		
Pa:	Philadelphia						11							10		
	Pittsburgh			<10								17				
P.R:	San Juan									<10						
R.I:	Providence										<10					
S.C:	Charleston			<10							212					
S. Dak:	Rapid City			12						12						
Tenn:	Chattanooga					<10							39			
	Memphis				<10								27			
Tex:	Austin			<10			72							87		
	Dallas			<10						58						
Utah:	Salt Lake City			<10						27						<10
Vt:	Burlington			<10								< 10				
Va:	Norfolk						<10							16		
Wash:	Seattle			<10		<10							<10			
	Spokane		<10				<10				<10					
W. Va:	Charleston							<10							11	
Wisc:	Milwaukee						<10							<10		
Wyo:	Laramie				<10							< 10				

Pasteurized Milk Network samples, January 1967

January 1967—Continued																Station location	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
44	15	26	-----	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	Ala:	Montgomery.
-----	-----	<10	-----	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	Alaska:	Palmer.
-----	-----	-----	11	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	Ariz:	Phoenix.
15	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	Ark:	Little Rock.
-----	-----	-----	11	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	<10	Calif:	Sacramento.
-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----		San Francisco.
<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	C.Z:	Cristobal.
-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	Colo:	Denver.
-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	14	-----	-----	-----	-----	Conn:	Hartford.
-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	17	-----	-----	-----	-----	-----	Del:	Wilmington.
-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	D.C:	Washington.
-----	-----	-----	18	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	Fla:	Tampa.
-----	-----	23	-----	21	-----	-----	-----	17	-----	<10	-----	-----	-----	-----	<10	Ga:	Altanta.
-----	11	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	Hawaii:	Honolulu.
<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	Idaho:	Idaho Falls.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	-----	Ill:	Chicago.
-----	11	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	Ind:	Indianapolis.
-----	<10	-----	<10	-----	10	-----	-----	<10	-----	<10	-----	<10	-----	-----	<10	Iowa:	Des Moines.
<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	Kans:	Wichita.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	Ky:	Louisville.
-----	-----	-----	28	-----	-----	-----	-----	-----	-----	10	-----	-----	-----	-----	-----	La:	New Orleans.
<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	14	-----	Maine:	Portland.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	Md:	Baltimore.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	13	Mass:	Boston.
-----	<10	-----	-----	-----	-----	-----	-----	12	-----	-----	-----	-----	-----	-----	11	Mich:	Detroit.
<10	-----	-----	-----	-----	-----	-----	11	-----	-----	-----	-----	-----	-----	<10	-----		Grand Rapids.
-----	10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	Minn:	Minneapolis.
42	-----	-----	-----	-----	-----	-----	20	-----	-----	-----	-----	-----	-----	<10	-----	Miss:	Jackson.
-----	-----	-----	-----	11	-----	-----	-----	-----	-----	-----	10	-----	-----	-----	-----	Mo:	Kansas City.
-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----		St. Louis.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	Mont:	Helena.
-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	Nebr:	Omaha.
-----	<10	-----	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	Nev:	Las Vegas.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	N.H:	Manchester.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	10	N.J:	Trenton.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	N. Mex:	Albuquerque.
-----	-----	-----	-----	40	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	N.Y:	Buffalo.
<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----		New York.
-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----		Syracuse.
12	-----	<10	-----	<10	-----	-----	10	-----	<10	-----	<10	-----	-----	<10	-----	N.C:	Charlotte.
<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	N. Dak:	Minot.
-----	10	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	10	-----	Ohio:	Cincinnati.
-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----		Cleveland.
-----	-----	17	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	-----	-----	Okla:	Oklahoma City.
-----	-----	-----	-----	10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	Ore:	Portland.
-----	-----	-----	-----	15	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	Pa:	Philadelphia.
-----	<10	-----	-----	-----	-----	-----	-----	14	-----	-----	-----	-----	-----	-----	-----		Pittsburgh.
<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	P.R:	San Juan.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	13	R.I:	Providence.
-----	18	-----	-----	21	-----	-----	<10	-----	13	-----	<10	-----	-----	<10	-----	S.C:	Charleston.
<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	S. Dak:	Rapid City.
-----	-----	15	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	Tenn:	Chattanooga.
-----	-----	-----	11	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----		Memphis.
-----	-----	-----	-----	19	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	Tex:	Austin.
50	-----	-----	-----	-----	-----	-----	10	-----	-----	-----	-----	-----	-----	<10	-----		Dallas.
-----	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	Utah:	Salt Lake City.
<10	-----	-----	-----	<10	-----	-----	-----	13	-----	-----	<10	-----	-----	-----	10	Vt:	Burlington.
-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	Va:	Norfolk.
-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	Wash:	Seattle.
-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	10		Spokane.
-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	W. Va:	Charleston.
-----	-----	-----	-----	<10	-----	-----	-----	-----	-----	-----	<10	-----	-----	-----	-----	Wisc:	Milwaukee.
-----	-----	<10	-----	-----	-----	-----	-----	-----	10	-----	-----	-----	-----	-----	<10	Wyo:	Laramie.

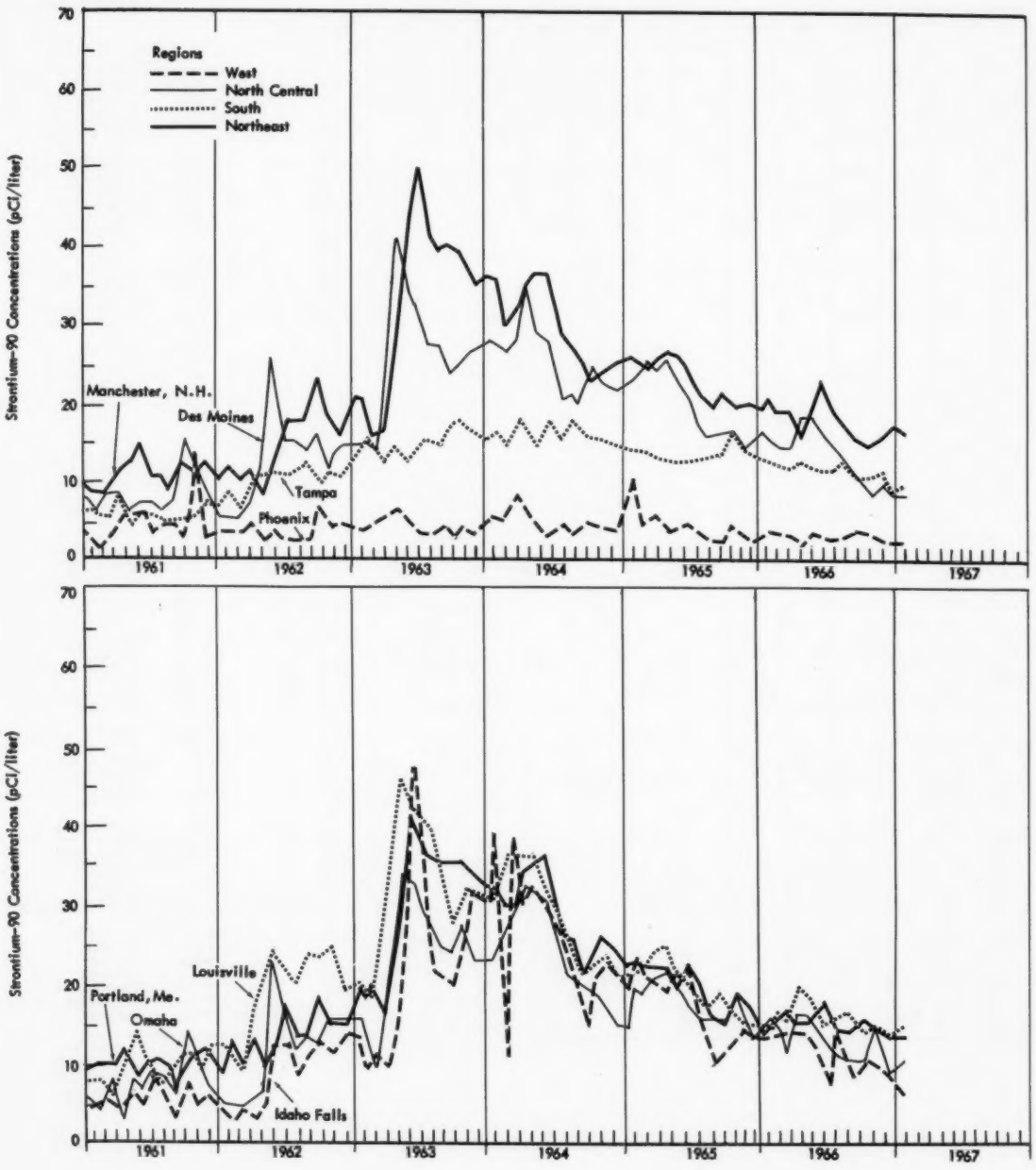

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-January 1967

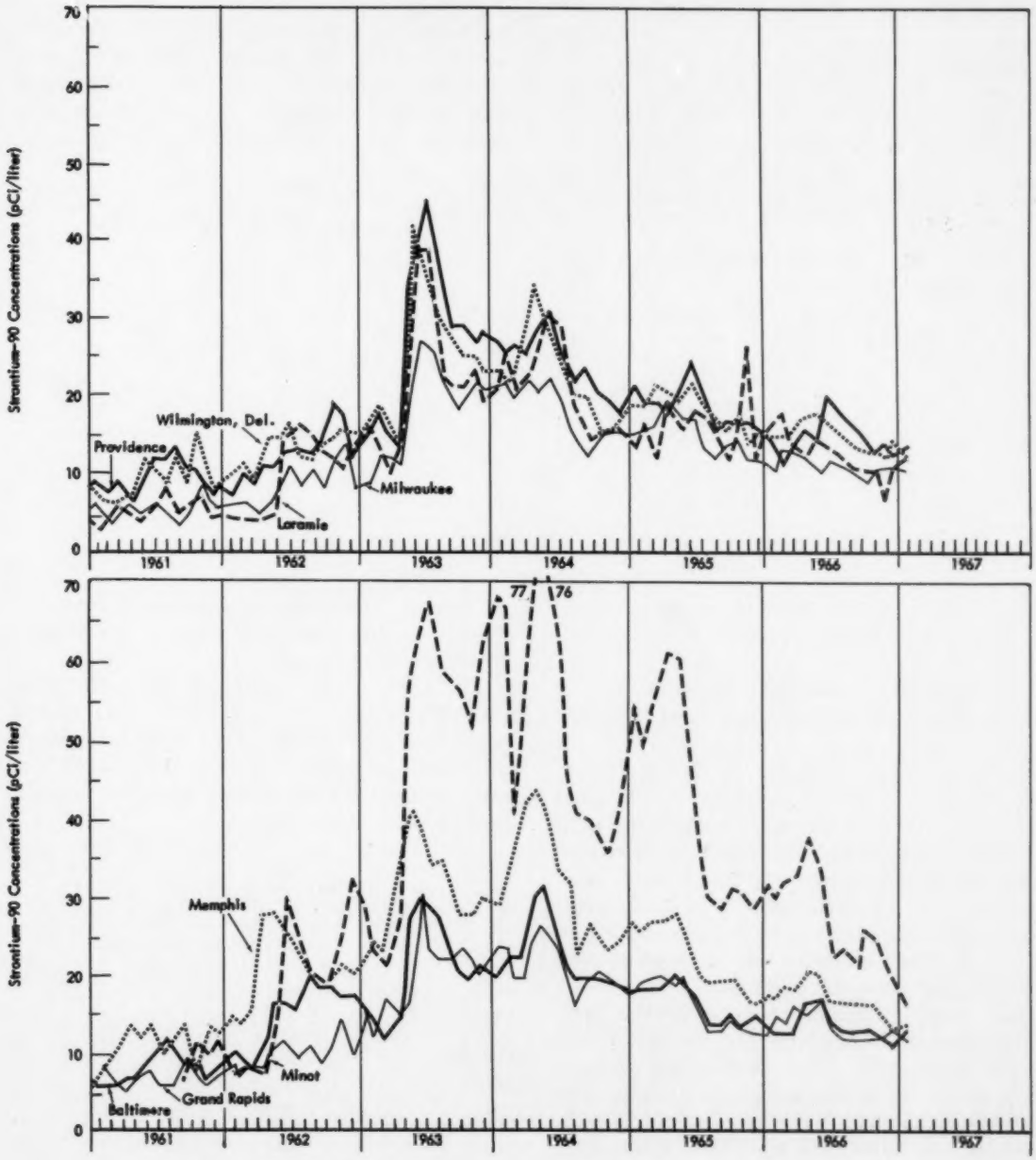

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-January 1967—Continued

mum detectable values; however, for iodine–131, zero was used for averaging purposes when concentrations were below minimum detectable levels.

Iodine–131 concentrations for January 1967 are shown in table 3. Concentrations greater than the minimum detectable level of 10 pCi/liter are presumed to reflect the fifth Chinese mainland atmospheric nuclear test of December 27, 1966, EST.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 4 and 5 for January 1966 and August 1966 through January 1967. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 4. Frequency distribution of monthly average strontium-90 concentrations in milk at PMN stations, January, August–December 1966, and January 1967

Strontium-90 (pCi/liter)	Number of stations						
	1966						1967
	Jan	Aug	Sept	Oct	Nov	Dec	Jan
Under 10	10	15	21	18	19	23	24
10–19	46	40	37	39	40	35	36
20–29	6	7	5	6	4	5	3
30–39	1	1	0	0	0	0	0

Table 5. Frequency distribution, cesium-137 concentrations in milk at PMN stations, January, August of monthly average December 1966, and January 1967

Cesium-137 (pCi/liter)	Number of stations						
	1966						1967
	Jan	Aug	Sept	Oct	Nov	Dec	Jan
Under 50	60	56	61	62	61	62	62
50–99	2	6	1	0	2	1	1
100–149	1	1	1	1	0	0	0

2. Canadian Milk Network January 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot-check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (*2*).

The January 1967 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 6. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

Table 6. Stable elements and radionuclides in Canadian whole milk, January 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.4	14	34
Edmonton	1.14	1.5	14	32
Ft. William	1.13	1.5	18	38
Fredericton	1.11	1.5	19	38
Halifax	1.11	1.5	17	40
Montreal	1.10	1.5	12	31
Ottawa	1.12	1.5	11	18
Quebec	1.08	1.6	18	44
Regina	1.02	1.4	10	20
St. John's, Nfld	1.12	1.5	21	59
Saskatoon	1.14	1.5	13	23
Sault Ste. Marie	1.12	1.5	18	35
Toronto	1.11	1.5	6	15
Vancouver	1.18	1.5	19	74
Windsor	1.14	1.5	6	19
Winnipeg	1.13	1.5	11	28
Average	1.12	1.5	14	34

[1] Prepared from February 1967 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

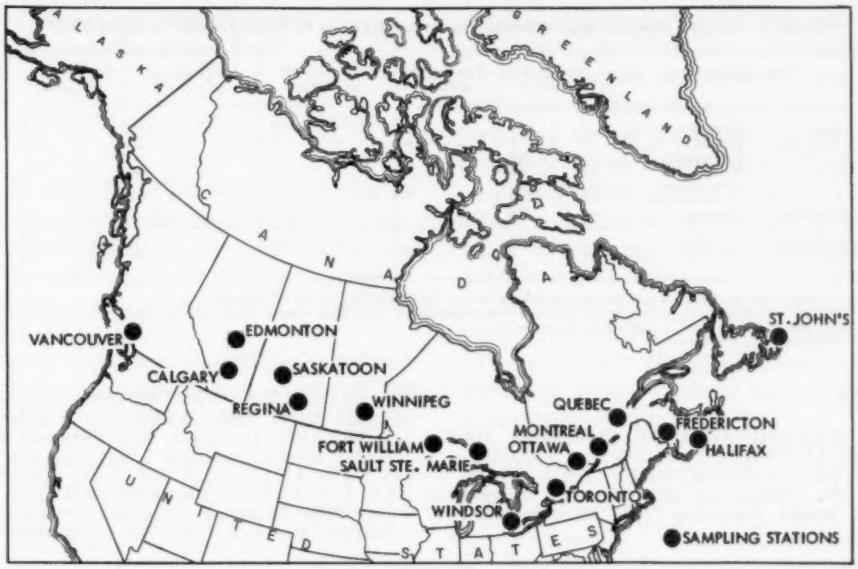

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program January 1967

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

Table 7 presents stable potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations for January 1967.

Figure 4. Pan American Milk Sampling Program locations

Table 7. Stable element and radionuclide concentrations in PAHO milk,[a] January 1967

Sampling station		Number of samples	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:	Santiago	4	1.7	<5	<1	<5
Colombia:	Bogotá	1	1.4	5	1	<5
Ecuador:	Guayaquil	NS				
Jamaica:	Kingston	1	1.4	5	9	105
	Mandeville	NS				
	Montego Bay	NS				
Venezuela:	Caracas	NS				
Canal Zone:	Cristóbal [b]	4		<5	7	35
Puerto Rico:	San Juan [b]	4		5	4	20

[a] Iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples.
[b] For comparison purposes, the radionuclide concentrations at Cristóbal, Canal Zone, and San Juan, Puerto Rico from the Pasteurized Milk Network are presented.
NS, no sample collected.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH and DIVISION OF ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION. Pasteurized Milk Network, August 1966. Radiol Health Data Rep 7:698-701 (December 1966).

(2) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702-703 (December 1966).

(3) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704-705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period covered	Last presented
California	July-September 1966	March 1967
Colorado	May 1965-June 1966	October 1966
Florida	April-June 1966	October 1966
Oklahoma	October–December 1966	April 1967
Oregon	July–September 1966	March 1967
Tennessee	July 1965–June 1966	April 1967
Texas	October–December and annual summary 1966	April 1967
Washington	July-September 1966	March 1967

1. Connecticut Milk Network October–December 1966

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, weekly samples representative of milk sold in the central area of the State are collected and analyzed for strontium-89, strontium-90, and gamma-ray emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and other gamma-ray emitters are determined by gamma-ray scintillation spectroscopy.

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 in Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2.

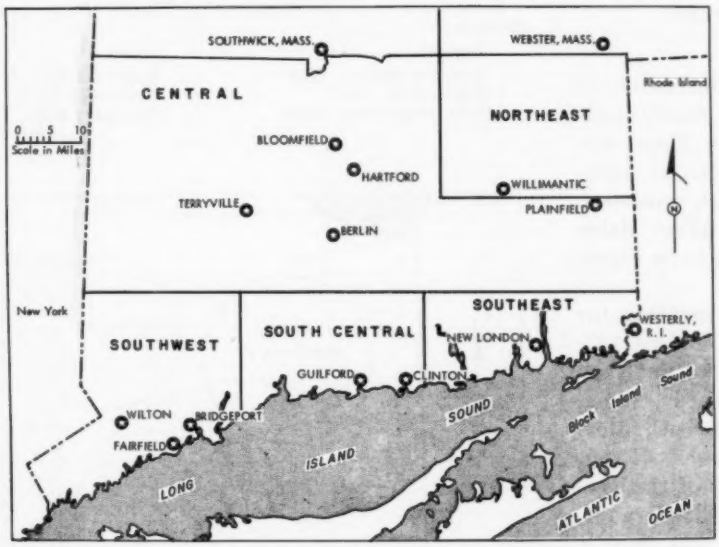

Figure 1. Connecticut pasteurized milk sampling areas

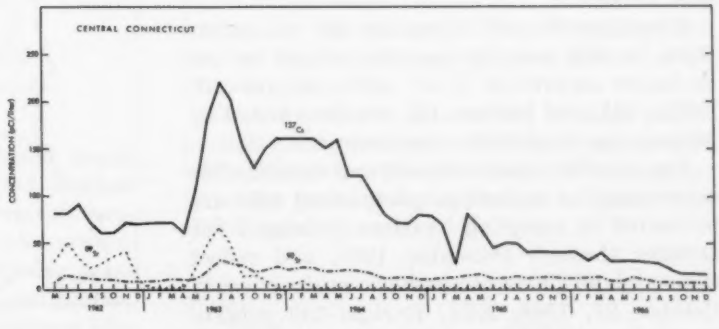

Figure 2. Radionuclide concentrations in central Connecticut pasteurized milk, May 1962-December 1966

Table 1. Radionuclide concentrations in central Connecticut milk, October–December 1966

Month 1966	Radionuclide concentrations (pCi/liter)			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
October	ND	9	<10	20
November	ND	9	<10	20
December	ND	9	<10	20

ND, below detectable levels.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–March 1966	August 1966
April–June 1966	November 1966
July–September 1966	February 1967

2. Indiana Milk Network October–December 1966

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: northeast, northwest, central, southeast, and southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed monthly for strontium–89 and strontium–90. Iodine–131, cesium–137, and barium–140 are analyzed weekly for at least two of the milksheds. When iodine–131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. From August 1963 to April 1966, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was once a month for the northeast, southeast, and southwest milksheds.

Strontium–89 and strontium–90 concentrations in milk samples are determined by ion exchange separation (*1–2*) while cesium–137, iodine–131, and barium–140 are determined by gamma-ray scintillation spectrometry (*3*).

The monthly stable element and radionuclide concentrations in Indiana pasteurized milk are presented by sampling locations in table 2 for October through December 1966, and reflect the mainland China atmospheric nuclear test of October 27, 1966, EST. Barium–140 concentrations remained below detectable levels of 10 pCi/liter during this period.

The monthly network average concentrations of strontium–89, strontium–90, and cesium–137 are presented graphically in figure 4.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1966	August 1966
April–June 1966	November 1966
July–September 1966	February 1967

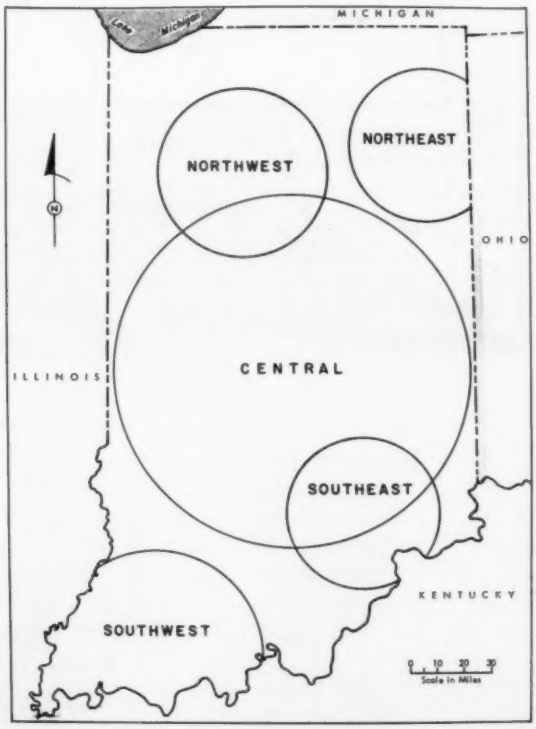

Figure 3. Indiana pasteurized milk sampling areas

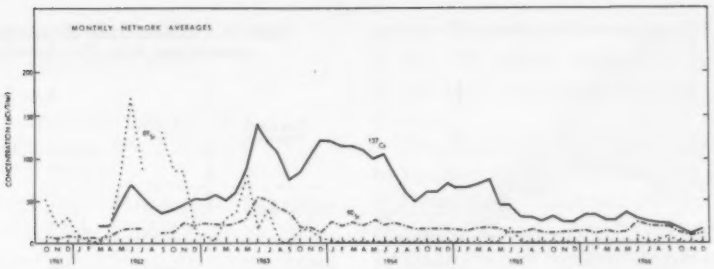
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
200
100
0
^{89}Sr
^{137}Cs
^{90}Sr
O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O
1961
1962
1963
1964
1965
1966

Figure 4. Radionuclide concentrations in Indiana pasteurized milk October 1961-December 1966

Table 2. Radionuclides in Indiana milk, October–December 1966

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-89 (pCi/liter)		
	October	November	December	October	November	December	October	November	December
Northeast	1.14	1.22	1.16	1,300	1,340	1,340	0	0	5
Southeast	1.10	1.30	1.16	1,320	----	1,350	0	0	0
Central	1.14	1.26	1.18	1,360	1,330	1,340	0	0	0
Southwest	1.14	1.24	1.18	1,310	1,270	1,270	0	0	0
Northwest	1.10	1.30	1.13	1,350	1,370	1,390	0	0	0
Average	1.12	1.26	1.16	1,330	1,330	1,340	0	0	0
	Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)		
Northeast	7	11	9	0	0	0	15	15	15
Southeast	12	8	12	0	----	0	15	----	20
Central	8	7	10	0	10	0	15	10	15
Southwest	12	12	13	0	10	0	10	10	10
Northwest	9	8	9	0	0	0	20	15	15
Average	10	9	11	0	0	0	15	10	15

3. Michigan Milk Network October–December 1966

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 5). Milkshed samples are composites from dairies in proportion to sales volume.

Strontium–90 concentrations are determined by an ion exchange method (*4*). Potassium–40, iodine–131, and cesium–137 concentrations are determined by gamma-ray scintillation spectrometry (*4*).

Table 3 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Strontium–90 and cesium–137 concentrations are presented graphically in figure 6 to show general trends.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–June 1966	November 1966
July–September 1966	February 1967

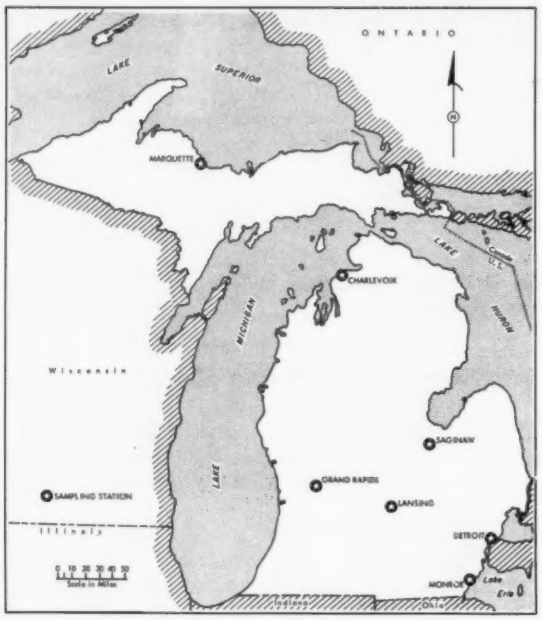

Figure 5. Michigan pasteurized milk network sampling locations

Table 3. Radionuclide concentration in Michigan pasteurized milk, October–December 1966

Sampling location	Month	Radionuclide concentrations (pCi/liter)			
		Potassium-40	Strontium-90	Iodine-131	Cesium-137
Charlevoix	October	1,340	6	<14	17
	November	1,320	5	<14	20
	December	1,310	8	<14	16
Detroit	October	1,330	4	<14	14
	November	1,290	4	<14	11
	December	1,360	NA	<14	11
Grand Rapids	October	1,310	5	<14	17
	November	1,360	7	<14	16
	December	1,350	7	<14	15
Lansing	October	1,350	4	<14	13
	November	1,350	4	<14	12
	December	1,360	6	<14	14
Marquette	October	1,350	NA	<14	30
	November	1,370	NA	<14	30
	December	NA	NA	<14	NA
Monroe	October	1,350	4	<14	10
	November	1,330	3	<14	15
	December	1,300	5	<14	9
Saginaw	October	1,300	4	<14	13
	November	1,300	5	<14	15
	December	1,360	5	<14	14
Average	October	1,330	5	<14	16
	November	1,330	5	<14	17
	December	1,340	6	<14	13

NA, no analyses.

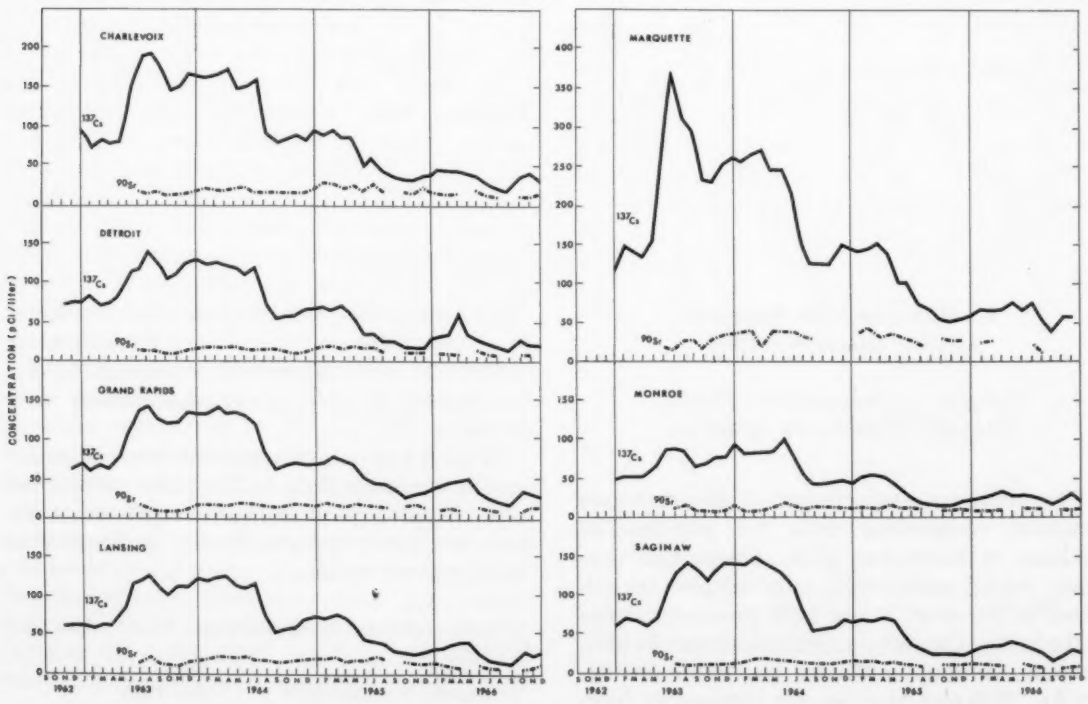

Figure 6. Radionuclide concentrations in Michigan pasteurized milk, 1962-December 1966

4. Minnesota Milk Network October–December 1966

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium–90 concentrations. Presently, monthly milk samples are collected from eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 7) and analyzed for strontium–90, iodine–131, and cesium–137 analyses. One-liter samples of processed Grade-A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health Department district offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned.

Strontium–90 concentrations are determined radiochemically, while iodine–131 and cesium–137 concentrations are determined by gamma-ray scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and the Rural Cooperative Power Association (*5*).

Strontium–90 and cesium–137 concentrations in milk are given for October through December 1966 in table 4, and are presented graphically by milkshed in figure 8 for the period 1962 through December 1966. Iodine–131 concentrations were less than 10 pCi/liter for the period October through December 1966.

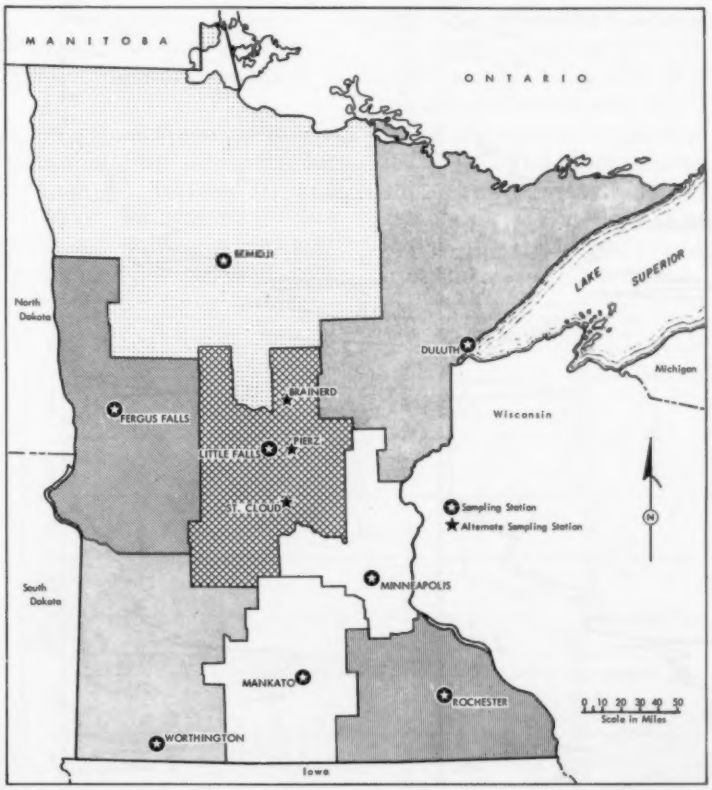

Figure 7. Minnesota milk sampling locations

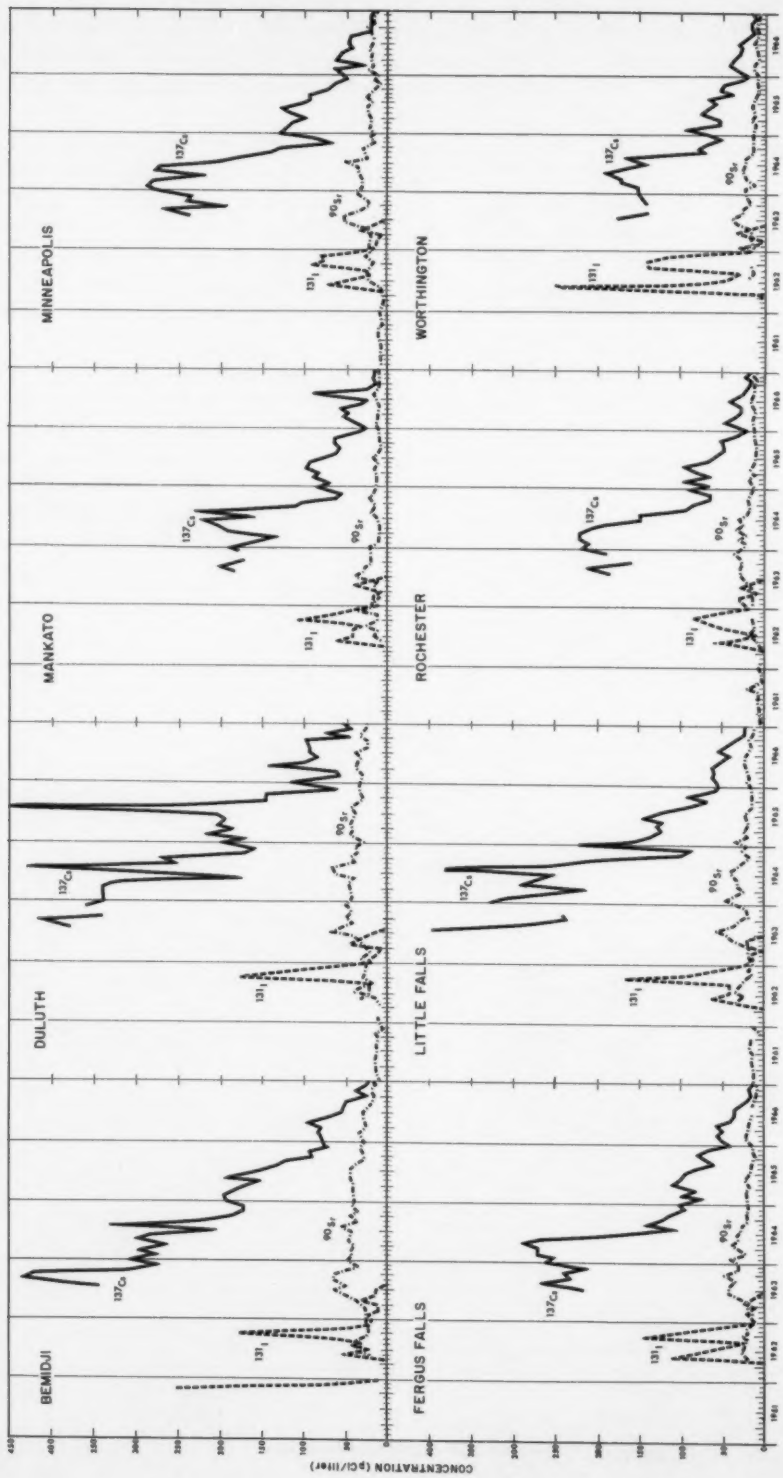

Figure 8. Radionuclide concentrations in Minnesota milk, 1961-December 1966

Table 4. Radionuclide concentrations in Minnesota milk, October–December 1966

Sampling location	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec
Bemidji	18	14	18	37	28	25
Mankato	7	8	11	15	14	14
Rochester	9	11	12	15	20	16
Duluth	31	27	25	82	40	53
Worthington	8	8	6	14	9	15
Minneapolis	14	14	10	21	22	19
Fergus Falls	12	11	12	15	18	14
Little Falls	12	11	10	28	23	23
Average	14	13	13	28	22	22

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–March 1966	August 1966
April–June 1966	November 1966
July–September 1966	February 1967

5. New York Milk Network October–December 1966

Division of Environmental Health Services
Department of Health, State of New York

Pasteurized milk samples collected routinely from six cities (figure 9) are analyzed for strontium–89, strontium–90, iodine–131, and barium-lanthanum–140 by the New York State Department of Health. At Buffalo, Newburgh, and Syracuse, milk samples are collected daily from processing plants, and composited weekly for radiochemical analyses. At Massena, samples are composited biweekly, while in New York City, a milk sample representing the total milk supply for 1 day is obtained and composited weekly for analysis. The Albany sample, taken at a marketing point, is analyzed daily for iodine–131 and other gamma-emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine–131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

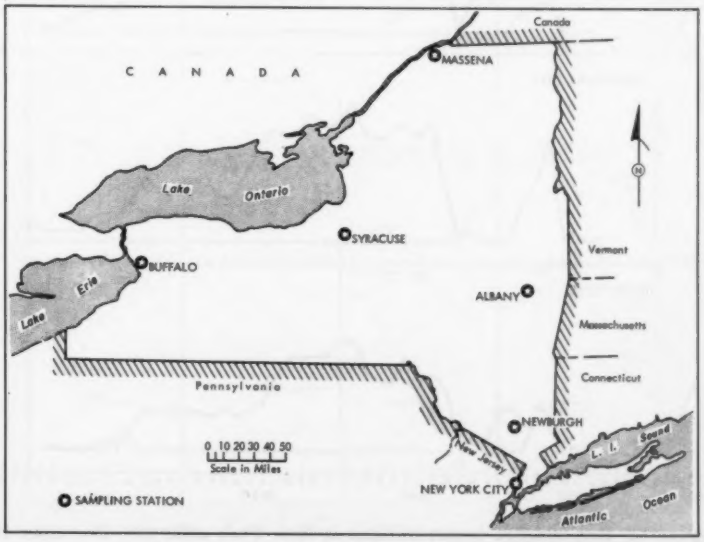

Figure 9. New York milk sampling stations

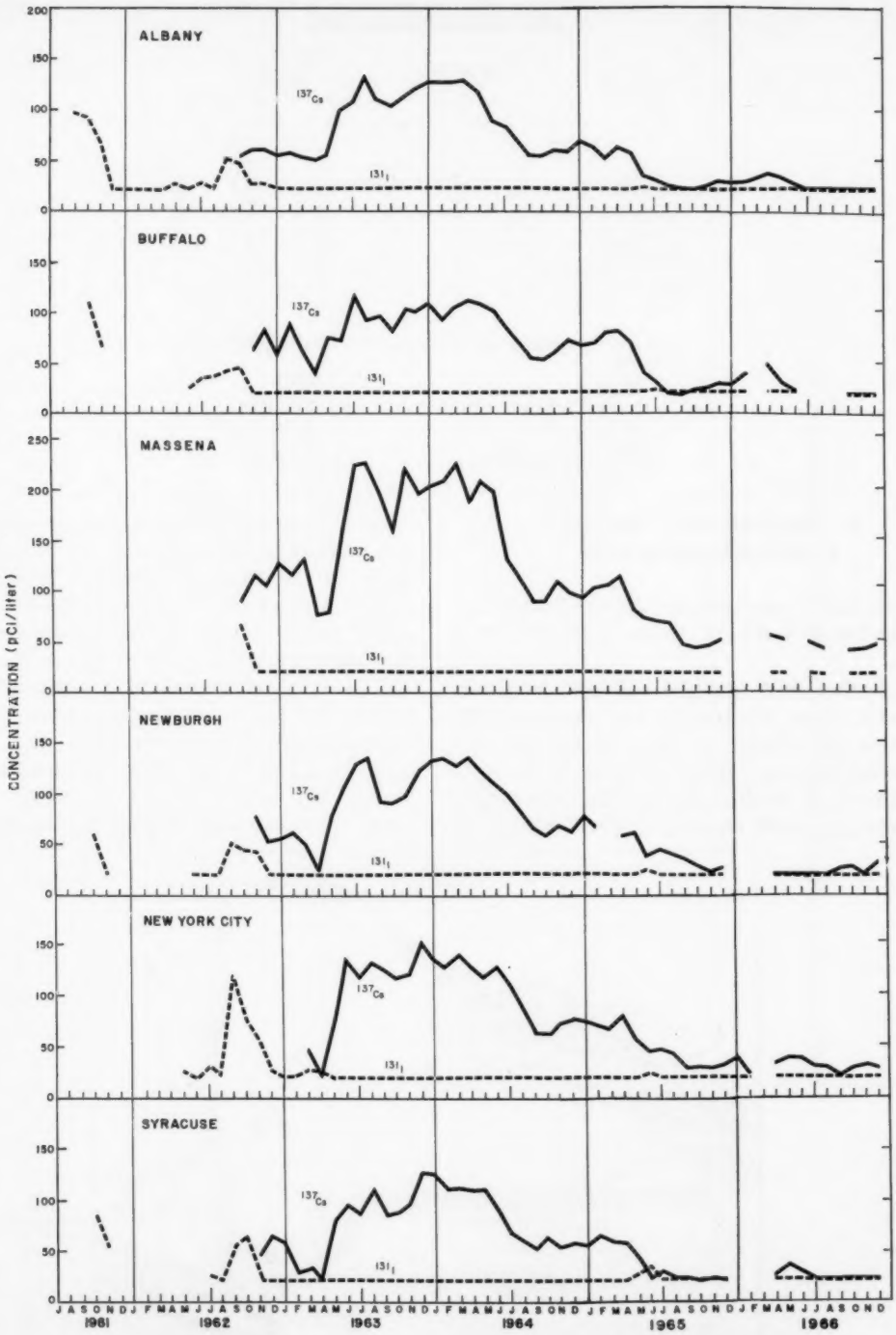
ALBANY
BUFFALO
MASSENA
NEWBURGH
NEW YORK CITY
SYRACUSE
137Cs
131I
CONCENTRATION (pCi/liter)
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1961
1962
1963
1964
1965
1966

Figure 10. Radionuclide concentrations in New York milk, 1961-December 1966

Gamma-emitting radionuclides in milk are determined by scintillation spectrometry and the application of a matrix method of analysis (*6*) to the resultant spectral data.

The analytical procedure for determining strontium–89 and strontium–90 concentrations employs an ion exchange system similar to that developed by Porter and Kahn (*2*).

The monthly average radionuclide concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 are shown in table 5 for October through December 1966. Cesium–137 and iodine–131 concentrations since September 1961 are presented graphically in figure 10.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–June 1966	November 1966
July–September 1966	February 1967

Table 5. Radionuclide concentrations in New York milk,[a] October–December 1966

Sampling location	Cesium-137 (pCi/liter)			Strontium-90 (pCi/liter)		
	October	November	December	October	November	December
Albany	<20	<20	<20	7	7	7
Ashford	NS			NS		
Bedford	NS			NS		
Buffalo	<20	<20	<20	7	8	8
Clarktown	<20	NA	<20	9	NA	8
East Otto	NS	NS	NS	NS	NS	NS
Massena	43	43	45	10	11	11
Middleburg	22	23	25	12	11	10
Mount Pleasant	26	27	27	10	7	8
Newburgh	28	25	39	10	11	10
New York	31	32	31	16	14	15
Oyster Bay	53	52	48	10	9	11
Syracuse	<20	<20	<20	6	7	9
Yaphank	NS			NS		
Yorkshire	NS			NS		
Yorktown	36	31	41	18	18	19
Average	23	28	29	9	9	11

[a] For this period, strontium-89 and iodine-131 concentrations were below their minimum detectable levels of 3 pCi/liter and 20 pCi/liter, respectively.
NA, no analysis.
NS, no sample collected.

6. Pennsylvania Milk Network October–December 1966

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 11). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health, in Harrisburg, where the weekly sample are com-

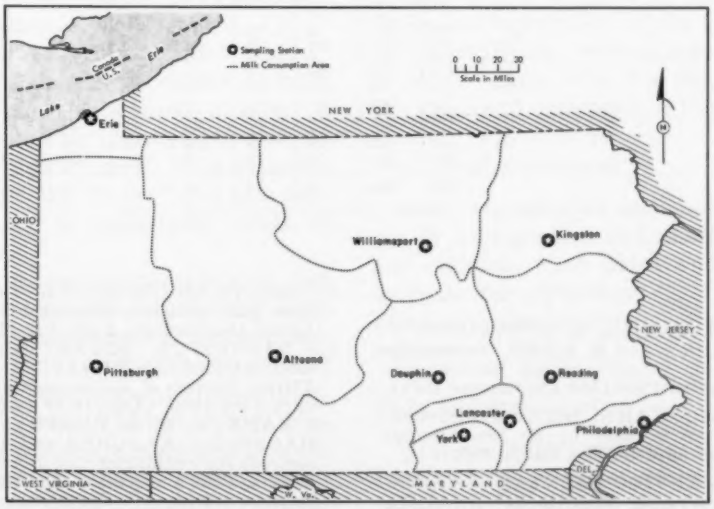

Figure 11. Pennsylvania pasteurized milk network sampling locations

bined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter and Kahn (*2*).

The monthly average potassium–40, strontium–90, iodine–131, and cesium–137 concentrations in pasteurized milk are given in table 6 for October through December 1966. For comparative purposes, strontium–90, iodine–131, and cesium–137 concentrations are presented graphically in figure 12.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–March 1966	August 1966
April–June 1966	November 1966
July–September 1966	February 1967

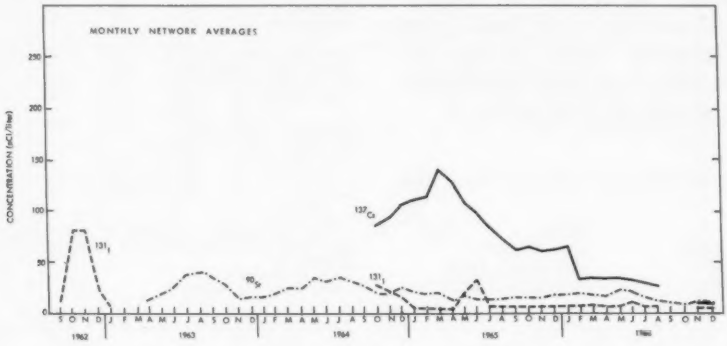
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
250
200
150
100
50
0
^{137}Cs
^{131}I
^{90}Sr
^{131}I
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1962
1963
1964
1965
1966

Figure 12. Radionuclide concentrations in Pennsylvania pasteurized milk, 1962-December 1966

Table 6. Radionuclide concentrations in Pennsylvania milk, October–December 1966

Sampling location	Radionuclide concentrations (pCi/liter)											
	Potassium-40			Strontium-90			Iodine-131			Cesium-137		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Altoona	[a]	798	901	8	14	14	[a]	<10	<10	[a]	16	15
Dauphin	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Erie	[a]	814	853	9	15	11	[a]	<10	<10	[a]	15	12
Kingston	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Lancaster	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Philadelphia	[a]	NS	908	12	NS	9	[a]	<10	<10	[a]	NS	8
Pittsburgh	[a]	855	867	12	16	17	[a]	<10	<10	[a]	12	13
Reading	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Williamsport	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
York	[a]	853	881	10	13	8	[a]	<10	<10	[a]	14	12
Average	.....	830	882	10	15	12	.....	<10	<10	.....	14	12

[a] Instrument out of order.
NS, no sample.

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium–90 in milk by an ion-exchange method. Anal Chem 33:1306-1308 (September 1961).

(*2*) PORTER, C., and B. KAHN. Improved determination of strontium–90 in milk by an ion-exchange method. Anal Chem 36:676-678 (March 1964).

(*3*) BUREAU OF ENVIRONMENTAL SANITATION, INDIANA STATE BOARD OF HEALTH. Indiana milk network, April-June 1965. Radiol Health Data 6:612-614 (November 1965).

(*4*) MICHIGAN DEPARTMENT OF HEALTH. Michigan milk network, November 1962-December 1964. Radiol Health Data 6:487-492 (September 1965).

(*5*) MINNESOTA DEPARTMENT OF HEALTH AND RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January-June 1965, COO-615-17 (August 1965).

(*6*) KAHN, B., G. K. MURPHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk, PHS Publication No. 999-R-2 (March 1963). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Food and Diet Surveillance Activities

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States.

---

1. Estimated Daily Intake of Radionuclides in California Diets, May–August 1966

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist, due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium–89, strontium–90, radium–226, and stable calcium, strontium, and sodium.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (May–June 1966) and table 2 (July–August 1966).

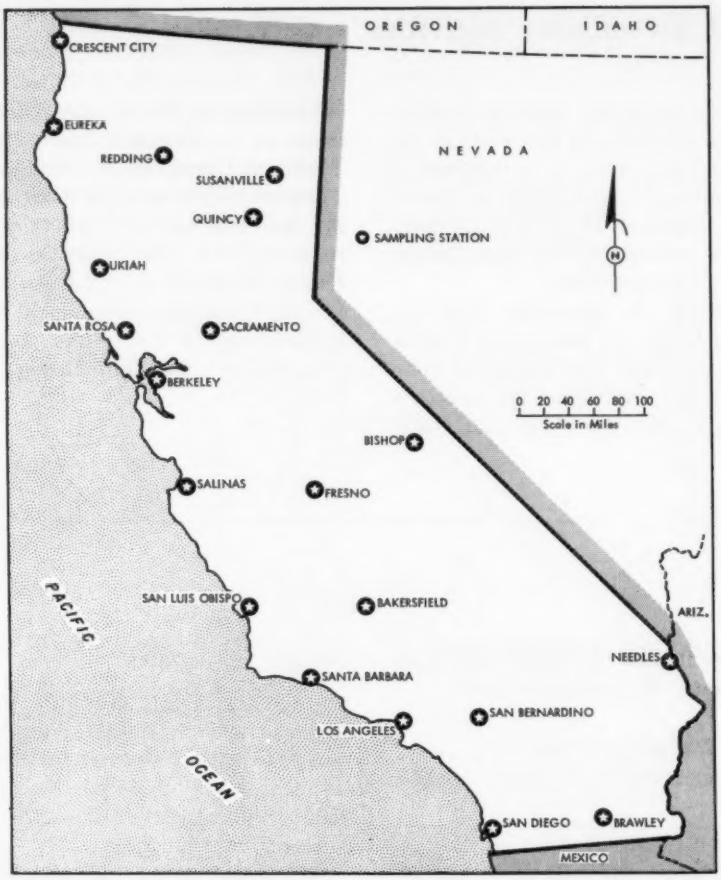

Figure 1. California diet sampling stations

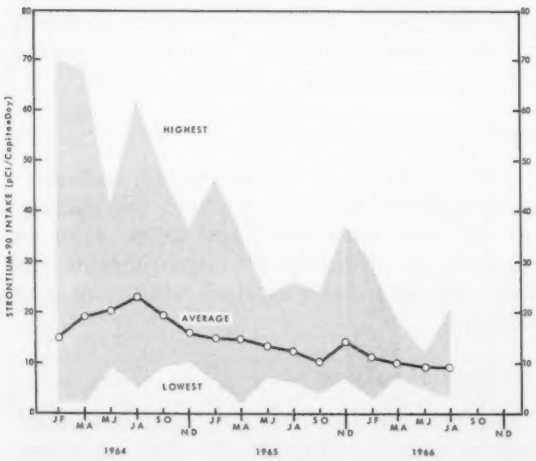

Figure 2. Averages and ranges of daily strontium-90 intake in California diets, 1964-August 1966

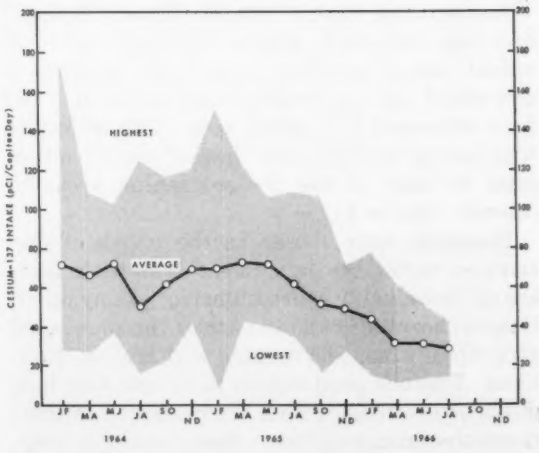

Figure 3. Averages and ranges of daily cesium-137 intake in California diets, 1964-August 1966

Table 1. Estimated daily intake of radionuclides in California diets, May–June 1966 [a]

City	Consumption (kg/capita-day [b])	Intake [c] (pCi/capita-day)				Intake (g/capita-day)			
		Strontium-90	Zirconium-95	Cesium-137	Radium-226	Potassium [d]	Sodium	Calcium	Stable strontium
Bakersfield	2.2	9	3	13	0.8	2.9	4.2	1.3	0.002
Berkeley	2.3	8	0	32	.7	2.0	3.2	1.0	.002
Bishop	2.2	8	0	44	.8	2.5	4.1	.6	.002
Brawley	2.0	10	0	22	1.7	2.9	4.5	.9	.005
Crescent City	2.1	13	2	32	.5	2.4	4.3	.8	.002
Eureka	2.2	12	0	38	.8	2.9	4.2	1.2	.004
Fresno	2.6	9	0	49	.8	2.7	4.9	.7	.002
Los Angeles	1.9	9	0	28	1.2	2.7	3.6	.8	.002
Needles	2.5	8	0	27	1.2	2.9	3.7	1.2	.003
Quincy	1.4	5	0	20	.3	1.8	2.7	.5	.001
Redding	2.4	12	0	37	1.3	2.7	4.3	1.4	.003
Sacramento	2.7	12	0	41	1.5	2.9	6.5	1.2	.003
Salinas	2.5	8	5	36	1.0	3.0	5.0	.9	.002
San Bernardino	1.9	7	0	26	1.5	2.7	3.7	.8	.003
San Diego	2.0	7	0	32	1.3	2.6	2.7	.8	.002
San Luis Obispo	1.4	7	1	24	.5	NA	NA	.9	NA
Santa Barbara	2.2	9	0	30	.5	3.0	4.0	1.1	.003
Santa Rosa	2.2	10	0	29	.8	2.3	3.1	1.1	.001
Susanville	1.7	7	1	26	.7	2.0	3.5	.7	.002
Ukiah	2.5	17	3	40	.6	2.8	3.9	1.6	.003

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in the diet.
[c] Manganese-54, cerium-141, and cerium-144 concentrations were non-detectable for this period.
[d] Natural potassium contains 0.0119 percent radioactive potassium-40.

Table 2. Estimated daily intake of radionuclides in California diets, July–August 1966 [a]

City	Consumption (kg/capita-day [b])	Intake [c] (pCi/capita-day)				Intake (g/capita-day)			
		Strontium-90	Zirconium-95	Cesium-137	Radium-226	Potassium [d]	Sodium	Calcium	Stable strontium
Bakersfield	2.3	6	0	23	0.7	2.7	4.0	1.1	0.002
Berkeley	2.6	10	1	36	1.1	2.6	3.1	1.0	.002
Bishop	2.1	6	3	32	.4	2.1	4.0	.8	.002
Brawley	1.5	3	4	18	.6	1.1	1.8	.6	.001
Crescent City	1.6	8	0	37	.4	1.8	3.4	.6	.001
Eureka	2.1	11	1	29	.6	2.2	3.9	1.0	.003
Fresno	2.1	21	0	31	2.1	3.4	7.1	1.6	.004
Los Angeles	2.4	7	0	27	1.3	2.7	3.7	.9	.002
Needles	1.8	9	0	22	.9	2.0	2.7	1.0	.003
Quincy	1.8	10	0	30	.9	2.8	7.7	.8	.003
Redding	1.9	10	0	28	.7	2.0	7.5	1.8	.003
Sacramento	2.7	13	0	42	1.4	2.7	5.1	2.9	.003
Salinas	2.4	10	0	34	.9	2.7	5.2	.8	.002
San Bernardino	1.7	6	0	15	.5	2.0	3.1	.6	.002
San Diego	2.1	6	0	32	.9	2.6	2.8	.7	.003
San Luis Obispo	1.4	4	0	29	1.0	1.8	3.0	.7	.001
Santa Barbara	2.1	8	0	24	.4	2.7	3.4	1.0	.002
Santa Rosa	2.3	8	3	29	.8	1.8	4.0	1.0	.002
Susanville	1.9	7	5	20	.2	2.0	3.9	.8	.002
Ukiah	2.7	8	1	29	.5	2.7	3.8	1.6	.002

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in the diet.
[c] Manganese-54, cerium-141, and cerium-144 concentrations were non-detectable for this period.
[d] Natural potassium contains 0.0119 percent radioactive potassium-40.

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. Stontium–90 intake in the California diet for the May–June 1966 period varied from 5 to 12 pCi/capita-day with an average of 9 pCi/capita-day. Cesium–137 intake varied from 13 to 49 pCi/capita-day with an average of 31 pCi/capita-day. For the July–August 1966 sampling period the strontium–90

intake varied from 3 to 21 pCi/capita-day with an average of 9 pCi/capita-day. Cesium–137 intake varied from 15 to 42 pCi/capita-day with an average of 28 pCi/capita-day. A summary of strontium–90 and cesium–137 intake trends in California diets from January 1964 through August 1966 is given in figures 2 and 3.

REFERENCES

(1) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Radiol Health News 3:3 (July 1964). 2151 Berkeley Way, Berkeley, Calif. 94704.

(2) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963-December 1964. Radiol Health Data 6:381-382 (July 1965).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–April 1965	March 1966
May–August 1965	June 1966
September–December 1965	September 1966
January–April 1966	January 1967

2. Estimated Daily Intake of Radionuclides in Connecticut Standard Diet, July–December 1966

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. Analyses are made for strontium–89, strontium–90, and gamma-ray emitters.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 3). The total weight of the complete blended diet, averaging 3 kilograms, includes milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Cesium–137 concentrations were determined by gamma-ray spectrometry (*1*). Strontium–89 and strontium–90 concentrations were determined by chemical separation techniques (*2*).

Table 3. Foods included in standard diet

Bread, white—8 slices	Ice cream—½ pint
Butter—½ stick	Lettuce, washed—4–5 leaves
Carrots, scraped—½ cup	Milk—3 cups
Celery, washed and trimmed—3 stalks	Oatmeal—uncooked—43 grams
Cookies—4	Orange—1
Cottage cheese—⅓ cup	Peanut butter—2½ tablespoons
Cupcakes—2	Pears, canned—2 halves with juice
Egg—1	Potatoes, washed, not peeled—2
Green beans, washed—½ cup	Sugar—5 tablespoons
Ham—85 grams	Tomato juice—113 grams
Hamburger—227 grams	Tuna fish, drained—43 grams

Table 4. Radionuclide concentrations in Connecticut standard diet, July–December 1966[a]

Month 1966	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
July	2.1	10	30
August	2.1	9	30
September	2.3	9	30
October	2.3	13	10
November	2.3	9	30
December	2.4	11	30

[a] All strontium-89 values were <3 pCi/kg for this period.

Table 4 presents the analytical results for the Connecticut standard diet from July through December 1966. Results representative of the total daily intake for the radionuclides observed are presented in table 5.

Table 5. Daily radionuclide intakes in Connecticut standard diet, July–December 1966[a]

Month 1966	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
July	6.1	28	90
August	6.3	26	80
September	6.5	27	80
October	7.4	43	40
November	6.8	27	100
December	7.1	32	90

[a] All strontium-89 values were <3 pCi/kg for this period.

In order to evaluate general trends, the strontium–90 and cesium–137 daily intakes are plotted as a function of time in figures 4 and 5.

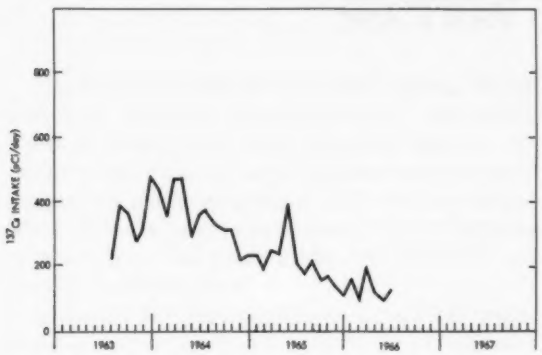

Figure 4. Cesium-137 intake in Connecticut standard diet, 1963-December 1966

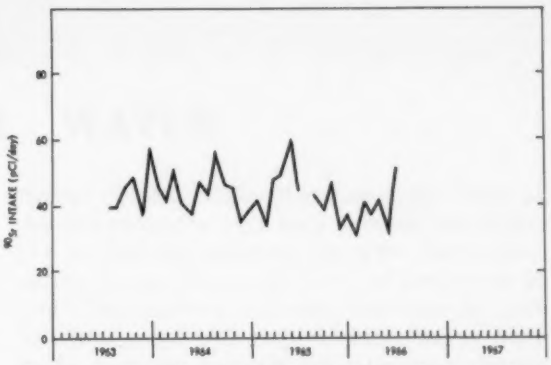

Figure 5. Strontium-90 intake in Connecticut standard diet, 1963-December 1966

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
March 1963–December 1964	July 1965
January–June 1965	February 1966
July 1965–June 1966	November 1966

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter, and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence [1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the safe limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Program	Period reported	Last presented
California Water Sampling Program	July–December 1965	November 1966
Coast Guard Water Sampling Program	1965	November 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Minnesota Surface Water Sampling Program	January–June 1966	January 1967
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostrontium in Tap Water, HASL	November 1965–June 1966	December 1966
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, November 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha- and beta-particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Detailed data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health

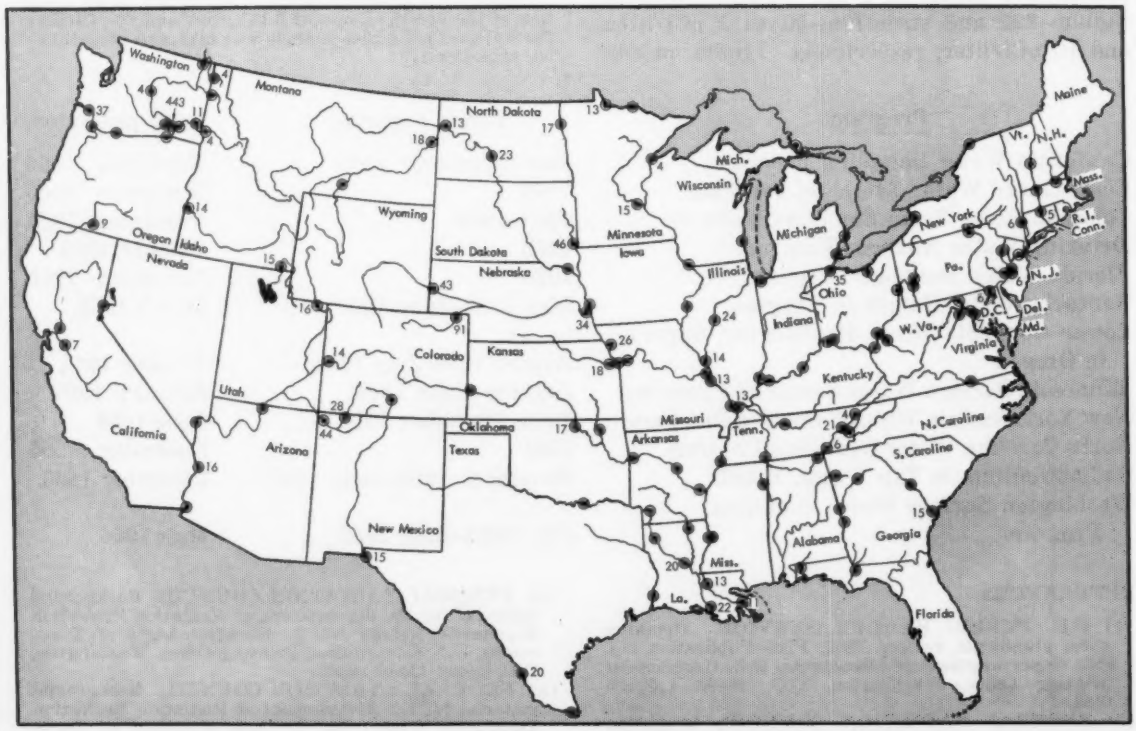

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, November 1966

significance, as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both October and November, the following stations showed alpha radioactivity in excess of 15 pCi/liter on either dissolved or suspended solids:

South Platte River; Julesburg, Colo.
North Platte River; Henry, Nebr.

During November the following stations declined in alpha radioactivity from the previous month to less than 15 pCi/liter on either dissolved or suspended solids:

Rio Grande; Laredo, Tex.
San Juan River; Shiprock, New Mex.
Colorado River; Loma, Colo.
Arkansas River; Coolidge, Kans.

On the Columbia River at Pasco, Wash., the beta radioactivity on dissolved solids showed an average of well over 150 pCi/liter.

Table 1. Radioactivity in raw surface waters, November 1966

Station	Average beta radioactivity (pCi/liter)			Average alpha radioactivity (pCi/liter)			Station	Average beta radioactivity (pCi/liter)			Average alpha radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Missouri River:						
Cedar Hill, N. Mex.	1	27	28	0	2	2	Williston, N. Dak.	2	11	13	0	5	5
Arkansas River:							Bismarck, N. Dak.	7	16	23	1	3	4
Ponca City, Okla.	1	16	17	0	2	2	St. Joseph, Mo.	7	19	26	1	3	4
Atchafalaya River:							North Platte River:						
Morgan City, La.	13	9	22	4	1	5	Henry, Nebr.	8	35	43	1	31	32
Bear River:							Ohio River:						
Preston, Idaho	0	15	15	0	3	3	Cairo, Ill.	6	7	13	1	0	1
Big Sioux River:							Pend Oreille River:						
Sioux Falls, S. Dak.	15	31	46	< 1	2	2	Albeni Falls Dam, Idaho	< 1	4	4	0	< 1	< 1
Chena River:							Platte River:						
Fairbanks, Alaska	1	2	3	0	< 1	< 1	Plattsmouth, Nebr.	10	24	34	2	6	8
Clearwater River:							Potomac River:						
Lewiston, Idaho	1	3	4	0	0	0	Washington, D.C.	1	6	7	0	0	0
Clinch River:							Rainy River:						
Clinton, Tenn.	1	3	4	0	0	0	Baudette, Minn.	1	12	13	0	0	0
Kingston, Tenn.*	6	15	21	0	0	0	Red River, North:						
Colorado River:							Grand Forks, N. Dak.	0	17	17	0	1	1
Loma, Colo.	2	12	14	0	8	8	Red River, South:						
Parker Dam, Calif.-Ariz.	0	16	16	0	4	4	Alexandria, La.	2	18	20	0	1	1
Columbia River:							Rio Grande:						
Wenatchee, Wash.	1	3	4	0	1	1	El Paso, Tex.	1	14	15	0	3	3
Pasco, Wash.*	44	399	443	< 1	< 1	< 1	Laredo, Tex.	8	12	20	2	5	7
Clatskanie, Ore.	11	26	37	0	< 1	< 1	San Joaquin River:						
Connecticut River:							Vernalis, Calif.	2	5	7	0	2	2
Enfield Dam, Conn.	1	4	5	0	0	0	San Juan River:						
Delaware River:							Shiprock, N. Mex.	32	12	44	12	5	17
Philadelphia, Pa.	1	5	6	0	0	0	Savannah River:						
Great Lakes:							Port Wentworth, Ga.*	3	12	15	0	0	0
Duluth, Minn.	1	3	4	0	0	0	Snake River:						
Green River:							Payette, Idaho	2	12	14	0	5	5
Dutch John, Utah	1	15	16	0	3	3	Wawawai, Wash.	2	9	11	0	3	3
Hudson River:							South Platte River:						
Poughkeepsie, N.Y.	1	5	6	0	0	0	Julesburg, Colo.	20	71	91	4	45	49
Illinois River:							Susquehanna River:						
Peoria, Ill.	15	9	24	5	1	6	Conowingo, Md.	1	5	6	0	0	0
Grafton, Ill.	3	11	14	1	0	1	Tennessee River:						
Kansas River:							Chattanooga, Tenn.	1	5	6	0	0	0
DeSoto, Kans.	2	16	18	0	2	2	Yellowstone River:						
Klamath River:							Sidney, Mont.	4	14	18	1	4	5
Keno, Ore.	2	7	9	0	0	0							
Maumee River:													
Toledo, Ohio	10	25	35	2	2	4	Maximum	44	399	443	12	45	49
Mississippi River:													
St. Paul, Minn.	1	14	15	0	1	1	Minimum	0	2	3	0	0	0
E. St. Louis, Ill.	1	12	13	0	1	1							
New Roads, La.	2	11	13	1	1	2							
New Orleans, La.	0	11	11	0	2	2							

* Gross beta activity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S Government Printing Office, Washington, D.C. 20402.

(*2*) *Ibid.*, 1959 Edition.

(*3*) *Ibid.*, 1960 Edition.

(*4*) *Ibid.*, 1961 Edition.

(*5*) *Ibid.*, 1962 Edition.

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1965	September 1966
HASL 80th Meridan Network	Calendar year 1965	January 1967

1. Radiation Surveillance Network January 1967

National Center for Radiological Health and *U.S. Public Health Service*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators prior to submission of the samples for laboratory analysis. When high air activity is reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during January 1967. Time profiles of gross beta in air for eight RSN stations are shown in figure 2.

Debris from the Chinese mainland atmospheric nuclear test of December 27, 1966 EST, crossed the United States for the first time during the first week of January 1967 and resulted in peak air gross beta radioactivity levels at many stations that were higher than have been noted since late 1962. Sixty air samples were above 10 pCi/m³. The three samples listed in table 2 exceeded 100 pCi/m³ at the time of collection. Four hundred and eighty gamma scans were performed on 467 air samples. Three hundred and twenty-nine of these were positive for fresh fission products.

Precipitation samples contained substantially higher radioactivity levels. The pattern of deposition was comparable in magnitude, but different in distribution, to the May 1966 findings.

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, January 1967

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	5	44.85	0.02	2.81		99	<20
Alaska:	Adak	31	------	.84	.00	.23		[c]	
	Anchorage	10	3	.51	.06	.20		14	<3
	Attu Island	26	------	.69	.00	.13		[c]	
	Fairbanks	16	4	.15	.02	.06		6	<2
	Juneau	16	10	.43	.00	.12		196	<47
	Kodiak	12	------	1.37	.04	.28		[c]	
	Nome	[b]	------	------	------	------		[c]	
	Pt. Barrow	24	------	.21	.04	.12		[c]	
	St. Paul Island	[b]	------	------	------	------		[c]	
Ariz:	Phoenix	31	------	55.65	.10	2.38		[c]	
Ark:	Little Rock	30	4	7.47	.03	.65		87	<18
Calif:	Berkeley	21	10	56.78	.08	7.93		245	<63
	Los Angeles	21	4	19.81	.07	3.19		157	<31
C.Z:	Ancón	16	------	.07	.01	.03		[c]	
Colo:	Denver	30	4	48.16	.03	2.41		14	<8
Conn:	Hartford	31	6	17.59	.01	1.04		40	<92
Del:	Dover	20	------	48.03	.02	2.20		[c]	
D.C:	Washington	28	6	28.46	.03	1.39		24	28
Fla:	Jacksonville	29	8	35.25	.01	1.59		34	<7
	Miami	30	6	56.90	.01	2.27		75	<19
Ga:	Atlanta	29	5	111.28	.02	5.28		119	<36
Guam:	Agana	29	------	.55	.00	.06		[c]	
Hawaii:	Honolulu	31	4	4.78	.01	.78		36	<16
Idaho:	Boise	31	5	84.71	.04	6.27		17	<49
Ill:	Springfield	31	4	14.39	.05	1.12		29	<15
Ind:	Indianapolis	30	5	10.10	.02	.72		40	<44
Iowa:	Iowa City	30	10	17.54	.08	1.29		22	355
Kans:	Topeka	31	2	6.35	.02	.58		14	<5
Ky:	Frankfort	27	3	24.56	.03	1.50		15	<7
La:	New Orleans	31	10	27.62	.02	2.10		89	<59
Maine:	Augusta	31	9	4.06	.03	.52		55	<39
	Presque Isle	19	------	3.45	.03	.35		[c]	
Md:	Baltimore	21	2	38.81	.00	1.73		10	4
	Rockville	14	------	35.38	.03	1.63		[c]	
Mass:	Lawrence	30	7	26.55	.03	1.54		33	<9
	Winchester	25	8	25.38	.03	1.31		53	<18
Mich:	Lansing	30	------	13.38	.04	.85		[c]	
Minn:	Minneapolis	20	9	1.92	.06	.28		70	<36
Miss:	Jackson	30	3	6.94	.01	.64		42	<10
Mo:	Jefferson City	29	3	7.79	.06	.79		27	<10
Mont:	Helena	31	3	10.72	.02	.74		11	<4
Nebr:	Lincoln	19	1	.33	.00	.12		5	2
Nev:	Las Vegas	28	------	119.35	.02	6.26		[c]	
N.H:	Concord	20	------	20.23	.09	1.34		[c]	
N.J:	Trenton	31	2	14.21	.02	.86		5	<3
N. Mex:	Santa Fe	26	1	23.17	.06	1.47		6	1
N.Y:	Albany	21	5	6.89	.04	.54		25	<6
	Buffalo	24	------	11.71	.02	.66		[c]	
	New York	31	------	13.06	.02	.98		[c]	
N.C:	Gastonia	30	7	24.14	.02	1.12		9	<39
N. Dak:	Bismarck	31	6	9.74	.04	.83		16	12
Ohio:	Cincinnati	17	------	19.73	.07	1.79		[c]	
	Columbus	31	3	23.30	.06	1.45		16	<4
	Painesville	28	5	6.45	.04	.54		25	<31
Okla:	Oklahoma City	30	2	5.87	.03	.56		26	<5
	Ponca City	30	2	5.39	.02	.26		20	<4
Ore:	Portland	30	23	51.64	.02	2.60		142	2,545
Pa:	Harrisburg	29	2	29.95	.03	1.27		43	15
P.R:	San Juan	31	7	.20	.02	.06		100	<20
R.I:	Providence	29	6	19.86	.02	1.01		41	<11
S.C:	Columbia	29	7	.65	.01	.21		53	<15
S. Dak:	Pierre	30	------	28.96	.02	1.51		[c]	
Tenn:	Nashville	31	4	31.96	.02	1.54		37	<51
Tex:	Austin	30	4	58.00	.04	2.75		6	<21
	El Paso	30	------	38.38	.07	3.10		[c]	
Utah:	Salt Lake City	30	10	104.52	.03	4.77		70	<125
Vt:	Barre	30	7	9.30	.04	.69		33	<205
Va:	Richmond	30	6	26.83	.01	1.33		21	<62
Wash:	Seattle	30	20	8.96	.01	.61		157	<73
	Spokane	31	5	36.49	.02	2.13		38	<61
W. Va:	Charleston	29	9	17.83	.04	1.47		25	<21
Wisc:	Madison	30	6	10.13	.03	.73		77	<256
Wyo:	Cheyenne	31	2	10.38	.02	.93		8	<2
Network summary		1,939	314	119.35	0.00	1.45		51	<86

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of 0.005 pCi/m³ or less are reported and used in averaging as 0.00 pCi/m³.
[b] No report received.
[c] No precipitation sample collected.

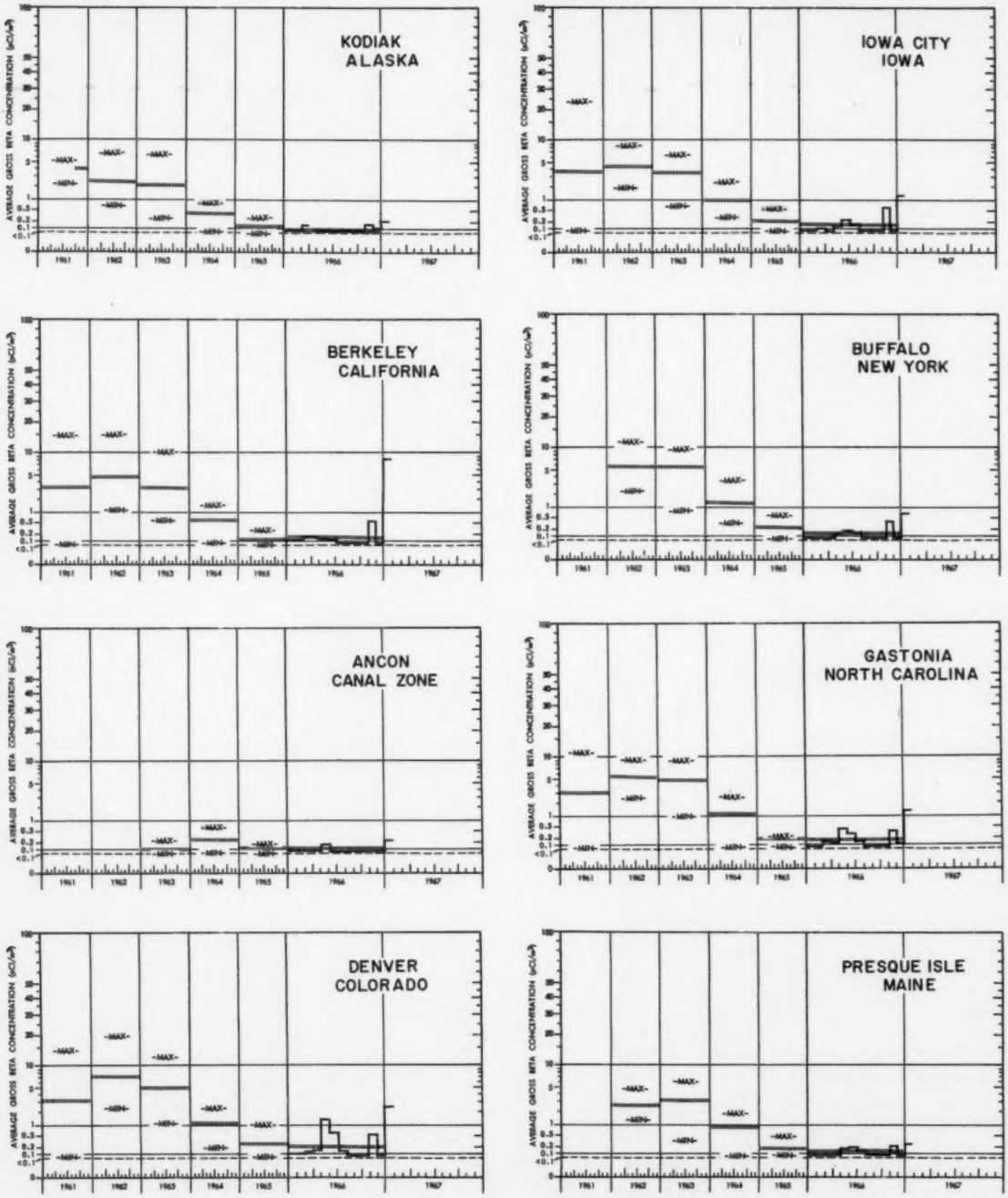

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1960-January 1967

Table 2. RSN stations with gross beta radioactivity in excess of 100 pCi/m³

Location	Date	Radioactivity (pCi/m³)
Las Vegas, Nev.	1/2/67	119.35
Salt Lake City, Utah	1/2/67	104.52
Atlanta, Ga.	1/4/67	111.28

The deposition in Portland, Ore., is the highest single monthly deposition since the present data collection system was established in November 1961. Precipitation samples analyzed by gamma-ray spectrometry yielded positive results for fresh fission products.

2. Canadian Air and Precipitation Monitoring Program, January 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for January 1967 are presented in table 3.

[1] Prepared from information and data in the February 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

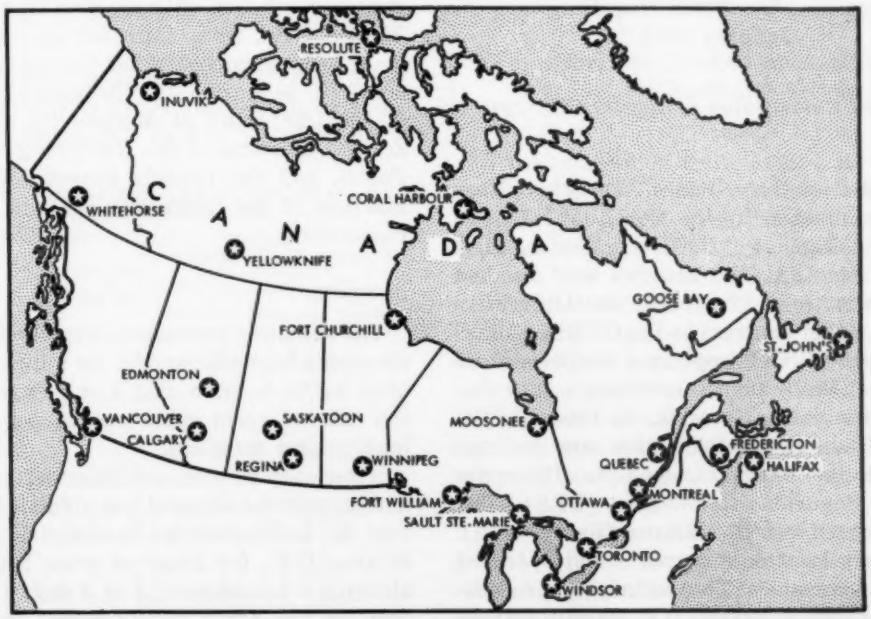

Figure 3. Canadian air and precipitation sampling stations

Table 3. Canadian gross beta radioactivity in surface air and precipitation, January 1967

Station	Number of samples	Air surveillance radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	290.0	0.1	13.2	271	5.6
Coral Harbour	29	6.3	.1	.6	645	6.4
Edmonton	31	32.0	.1	1.7	174	5.1
Ft. Churchill	31	.8	.0	.2	25	.8
Ft. William	31	6.2	.0	.7	287	8.1
Fredericton	30	13.5	.0	1.2	133	10.5
Goose Bay	31	.3	.1	.2	NS	NS
Halifax	31	4.3	.0	.5	42	4.8
Inuvik	31	1.4	.0	.2	79	1.5
Montreal	31	38.0	.1	3.5	942	52.1
Moosonee	31	6.8	.1	.5	48	1.5
Ottawa	31	50.0	.1	3.0	671	47.3
Quebec	31	3.6	.0	.7	254	24.4
Regina	31	14.0	.1	1.4	166	4.5
Resolute	31	2.0	.1	.4	272	.3
St. John's, Nfld.	31	1.4	.1	.2	29	5.2
Saskatoon	31	5.7	.1	.6	232	4.8
Sault Ste. Marie	31	3.2	.1	.6	190	19.8
Toronto	31	59.0	.0	3.6	1,438	78.8
Vancouver	31	3.2	.0	.3	36	8.3
Whitehorse	31	.4	.0	.2	119	2.4
Windsor	31	17.0	.1	1.3	101	5.3
Winnipeg	31	19.4	.1	1.6	123	2.5
Yellowknife	31	5.2	.1	.4	307	1.8
Network summary	741	290.0	0.0	1.5	286	13.1

NS, no sample.

3. Mexican Air Monitoring Program January 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta activity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collec-

Figure 4. Mexican air sampling locations

tion. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average activity at each station (*7*).

The maximum, minimum, and average gross beta radioactivity in surface air during January 1967 are presented in table 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, January 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	8	0.2	<0.1	0.1
Chihuahua	10	.7	.1	.2
Ciudad Juárez	3	4.6	.6	
Ensenada	6	.6	.1	.2
Guadalajara	2			
Guaymas	9	.7	.1	.3
La Paz	3	.3	.1	.1
Matamoros	NS			
Mazatlán	8	.2	< .1	.1
Mérida	3	.4	.1	
México, D.F.	3	.1	< .1	
Nuevo Laredo	7	.4	.1	.1
San Luis Potosí	1			
Tampico	9	.1	< .1	.1
Torreón	8	.3	.1	.2
Veracruz	7	.3	< .1	.1

NS, no sample collected, station temporarily shut down.

4. Pan American Air Sampling Program January 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed by the Radiation Surveillance Network. The air-sampling station positions are shown in figure 5.

The January 1967 air-monitoring results from the participating countries are given in table 5. Two changes from previous reports are the addition of a station at La Paz, Bolivia, and change in minimum reporting levels and

Figure 5. Pan American Air Sampling Program stations

conventions. The change involves the elimination of the "less than" sign (<) from the tabulation. Air values are now rounded to the nearest 0.01 pCi/m³ with values of 0.0050 or less reported and used in averaging as 0.00 pCi/m³.

The air radioactivity levels continued to decrease from December 1966 levels. The most active sample was collected at Buenos Aires, Argentina, on January 13, 1967, and measured 0.28 pCi/m³ when counted on January 23, 1967.

No fresh fission products were identified on PAHO air samples during January 1967.

Table 5. PAHO gross beta radioactivity in surface air, January 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	23	0.28	0.06	0.17
Bolivia: La Paz	26	.09	.00	.03
Chile: Santiago	25	.20	.05	.11
Colombia: Bogota	20	.11	.00	.02
Ecuador: Guayaquil	26	.15	.01	.05
Jamaica: Kingston	10	.05	.02	.03
Peru: Lima	3	.11	.08	.09
Venezuela: Caracas	17	.11	.01	.04
West Indies: Trinidad	21	.14	.01	.05
Pan American summary	171	0.28	0.00	0.03

[a] The monthly average is calculated by weighting the individual samples with length of sampling period.

5. Plutonium in Airborne Particulates October–December 1966

National Center for Radiological Health
U.S. Public Health Service

The Radiation Surveillance Network (RSN) of the National Center for Radiological Health, Public Health Service, located at Rockville, Maryland, is continuing routine analysis for plutonium in air particulates. These analyses were initiated during 1965 as part of the mission to establish, maintain, and operate a national surveillance network to measure radioactivity in the environment.

Air filters from 11 RSN stations are analyzed monthly for plutonium. Each daily filter is counted for gross beta radioactivity and for gamma-ray emitters by gamma spectroscopy 4 to 5 days after collection. For plutonium analysis, a monthly composite is made of one-half of each individual sample for each station. Each composite, representing 10,000 to 20,000

Table 6. Plutonium in airborne particulates October–December 1966

Sampling location	Plutonium content [a] (pCi/1,000m³)		
	October	November	December
Alaska: Anchorage	0.034	0.026	0.095
Ariz: Phoenix	.067	.053	.082
Colo: Denver	.042	.041	.035
Hawaii: Honolulu	.029	.026	.024
La: New Orleans	.046	.032	.045
Md: Rockville	.040	.036	.033
N.Y: Buffalo	.034	.033	.032
N.C: Gastonia	.036	.048	.036
S. Dak: Pierre	.037	.025	.032
Tex: Austin	.054	.047	.042
Wash: Seattle	.031	.027	.030

[a] Plutonium includes ^{238}Pu, ^{239}Pu, and ^{240}Pu.

cubic meters of air, is analyzed by gamma-ray spectrometry prior to the plutonium analysis.

Details of the method of collection and radiochemical analyses were presented in an earlier report (*8*). The results for October through December 1966 are presented in table 6.

REFERENCES

(*1*) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. National Center for Radiological Health, Public Health Service. Rockville, Md. 20852 (distribution by official request).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*4*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*5*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*6*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*7*) VASQUEZ, M., and R. M. DeNULMAN. Estudios sobre la Radioactividad Ambiental en la República Mexicana, 1963-1965. Comisión Nacional de Energía Nuclear. Dirección General de Seguridad Radiológica (en prensa 1966).

(*8*) RUSSELL, J., H. LEVINE, and R. SCHNEIDER. Plutonium in airborne particulates. Radiol Health Data Rep 7:483-484 (August 1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring reports.

Radionuclides in Alaskan Caribou and Reindeer October–November 1966

National Center for Radiological Health
U.S. Public Health Service

Under a cooperative agreement between the Alaskan Department of Health and Welfare, the Alaskan Department of Fish and Game, and the U.S. Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. The basis for this joint sampling activity was a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou (*Rangifer caribou*) herds and one privately owned reindeer (*Rangifer tarandus*) herd. This program was expanded in September 1964, when the sampling of additional privately owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and the Bureau of Indian Affairs, Department of Interior.

Figure 1 shows the locations and approximate number of animals in the caribou and reindeer herds sampled during the fall of 1966.

For the present program, samples are taken in the spring and fall from selected caribou and reindeer herds. Five muscle and rumen content samples are obtained from each herd during the sampling period. Five hock bones are collected from the Nome herd at the fall collection period. Muscle samples are analyzed individually and rumen content samples from the same herd are composited before analysis for cesium–137 by gamma-ray spectroscopy. Muscle and bone samples from the same herd are composited before analysis for strontium–89 and strontium–90. All samples are analyzed at the Public Health Service's Southwestern Radiological Health Laboratory in Las Vegas, Nev.

Strontium–89, strontium–90, and cesium–137 data are presented in table 1 for caribou and reindeer muscle, rumen contents, and bone for the October–November 1966 collection period. The muscle data are of prime interest, since muscle is an important constituent of the diet for many Alaskan residents. The five herds sampled in the fall of 1966 had average cesium–137 muscle concentrations similar to those found for the fall 1965 samples with the exception of the Arctic herd samples. The average cesium–137 muscle sample concentrations of the Arctic herd were more than double the average for fall 1965 samples and were similar to spring samples. The reason for this is not known, however, it is possible that the Arctic herd was forced to return to a winter diet of lichen and sedges (high in cesium–137 content) earlier this year. A summary of strontium–90 and cesium–137 concentrations in foodstuffs in Alaska (including reindeer and caribou meat) is contained in the December 1966 issue of *Radiological Health Data and Reports*.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
1963–1965	March 1966

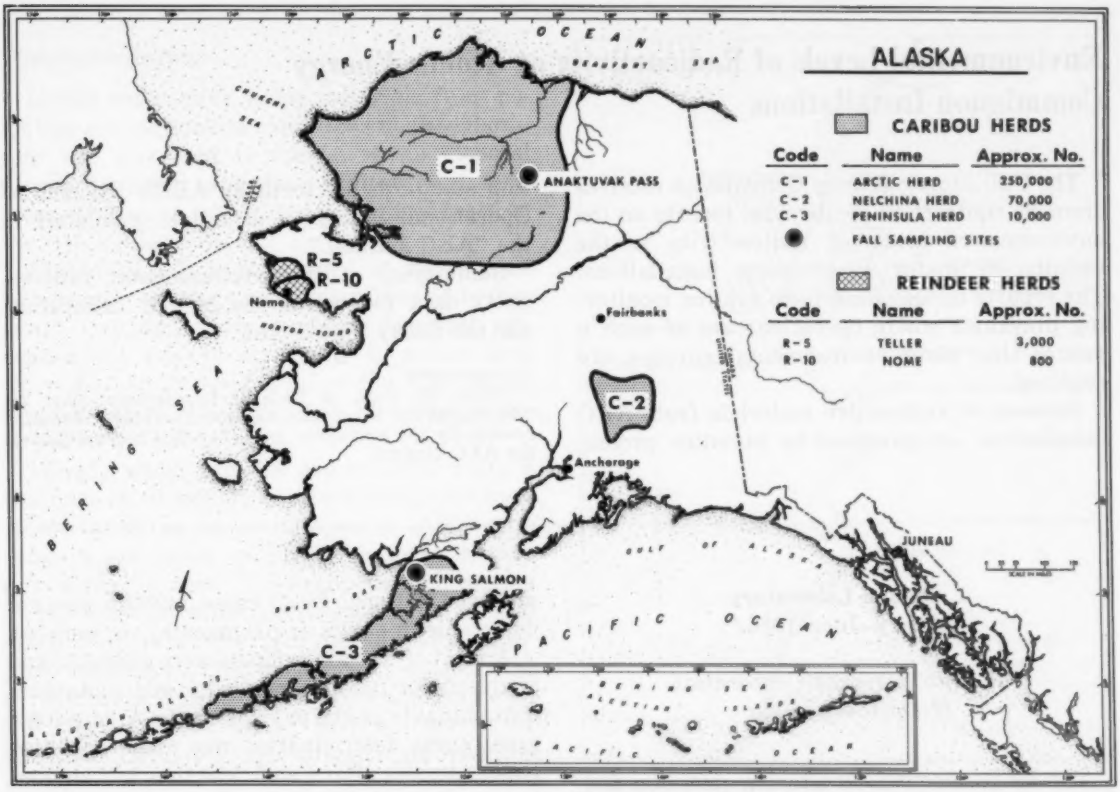

Figure 1. Location and numbers of caribou and reindeer in herds sampled

Table 1. Radionuclide concentrations in muscle, rumen, and bone of Alaskan caribou and reindeer, October–November 1966

Herd and sampling location [a]	Collection date, 1966	Sex	Age (years)	Muscle (pCi/kg wet weight)			Rumen (pCi/kg wet weight)		Bone (pCi/g ash)
				^{89}Sr [b]	^{90}Sr [b]	^{137}Cs	^{90}Sr [b]	^{137}Cs [b]	^{90}Sr [b]
Arctic caribou herd, Anaktuvuk Pass, C–1	10/8	M	2	<5	9	25×10^3	NA	7.9×10^3	NS
	10/12	M	2			10×10^3			
	10/12	M	3			14×10^3			
	10/17	F	5			16×10^3			
	10/18	F	4			20×10^3			
Nelchina caribou herd, Dickey Lake, C–2	10/4	M	4	<5	22	11×10^3	NA	7.2×10^3	NS
	10/4	M	4			12×10^3			
	10/4	F	6			13×10^3			
	10/4	M	4			13×10^3			
	10/4	F	5			14×10^3			
Peninsula caribou herd, King Salmon, C–3	11/2	M	5	<5	5	18×10^3	NA	7.0×10^3	NS
	11/2	F	6			18×10^3			
	11/2	M	1			25×10^3			
	11/2	M	6			19×10^3			
	11/2	M	3			19×10^3			
Teller reindeer herd, R–5	11/25	F	5	<5	9	23×10^3	NA	8.2×10^3	NS
	11/25	M	3			19×10^3			
	11/25	M	4			27×10^3			
	11/25	M	5			35×10^3			
	11/25	M	4			24×10^3			
Nome reindeer herd, R–10	11/9	F	2	NA	377	22×10^3	3,190	12×10^3	187
	11/9	F	2			26×10^3			
	11/9	F	4			28×10^3			
	11/9	F	2			20×10^3			
	11/9	M	2			27×10^3			

[a] Sampling locations are shown on figure 1.
[b] Composite of individual samples taken within the herd.
NA, no analysis.
NS, no sample taken.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Mound Laboratory and the Rocky Flats Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Mound Laboratory January–June 1966 [2]

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specific for the radionuclides which could be released to the environment. Only polonium–210, plutonium–239, and hydrogen–3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha emitters was used in the routine monitoring of environmental air in a network of 111 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

During the 6-month period ending June 1966, weekly samples were collected and analyzed for airborne tritium. In all cases, tritium was not detectable in offsite environmental air samples.

A total of 212 air samples were collected and analyzed for possible polonium and plutonium contaminants in the environment. A long-lived gross alpha determination was made on filter-paper samples after a sufficient time had elapsed to permit the decay of the short-lived daughter products of radon and thoron. The filter paper samples were counted for alpha-particle emissions in a low-background proportional counter. The average measured concentrations of alpha-particle activity in air are summarized in table 1. No specific determinations of polonium–210 or plutonium–239 were made, since the gross alpha-particle activity remained substantially below the environmental limits for these nuclides.

Table 1. Atmospheric monitoring of long-lived alpha radioactivity, Mound Laboratory environs, January–June 1966

Sampling location	Number of samples	Concentration (pCi/m³)	
		Maximum	Average [a]
Upwind from laboratory	25	[b] 0.0035	0.0035
Downwind from laboratory	187	.1112	.0054

[a] The applicable AEC Radiation Protection Standards for uncontrolled areas are as follows:
Polonium-210 in air: 20 pCi/m³
Plutonium-239 in air: 0.06 pCi/m³

[b] The minimum detectable concentration for long-lived alpha radioactivity concentrations in air is 0.0035 pCi/m³.

[2] Summarized from "Environmental Monitoring Report: January-June 1966" (MLM-1356).

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium–3, which is purified at the Mound Laboratory, contains small quantities of hydrogen–3 (tritium). Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the AEC radiation protection standard before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and six locations along the Great Miami River as shown in figure 1. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and treated liquid tritium and plutonium wastes from the plant site. Sampling location number 3 (figure 1) is the point of discharge of the liquid polonium waste to the Great Miami River; and number 7, at Franklin, Ohio, is 5 miles downstream from the effluent outfall.

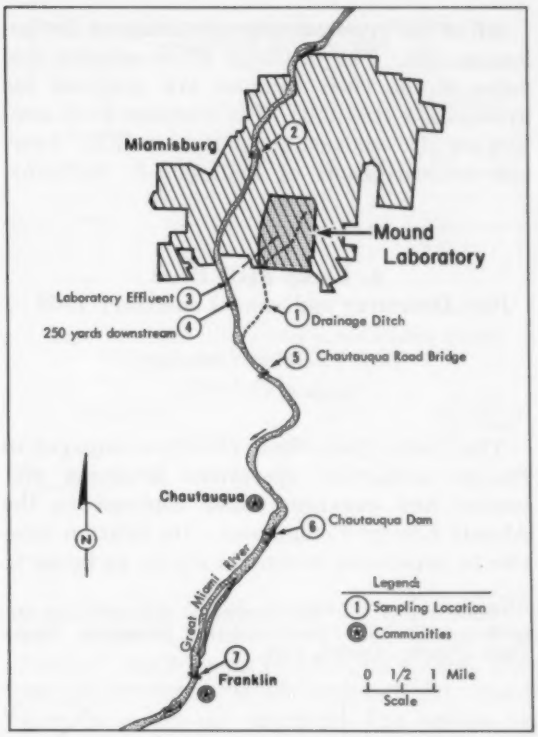

Figure 1. Water sampling locations, Mound Laboratory

Table 2. Offsite water monitoring for radioactivity, Mound Laboratory environs, January–June 1966

Nuclide and sampling location [a]	Number of samples	Concentration (pCi/liter)	
		Maximum	Average [b]
Polonium-210 [c]			
2 (Upstream from laboratory)	26	1.80	1.80
3 (Laboratory effluent)	26	1.68×10^{3}	1.04×10^{3}
4 (250-yards downstream)	26	3.60	1.94
5 (Chautauqua Road Bridge)	26	1.80	1.80
6 (Chautauqua Dam)	26	1.80	1.80
7 (Franklin, Ohio)	26	2.70	1.84
Trenton, Ohio	2	1.80	1.80
New Miami, Ohio	2	1.80	1.80
7 miles upstream from New Baltimore, Ohio	2	1.80	1.80
New Baltimore, Ohio	2	1.80	1.80
Elizabethtown, Ohio	2	1.80	1.80
Hydrogen-3 (tritium) [d]			
1 (drainage ditch)	25	7.10×10^{6}	$.40\times10^{6}$
2 (Upstream from laboratory)	25	$.22\times10^{6}$	$.06\times10^{6}$
3 (Laboratory effluent)	25	3.50×10^{6}	$.38\times10^{6}$
5 (Chautauqua Road Bridge)	24	$.27\times10^{6}$	$.07\times10^{6}$
Plutonium-239 [e]			
1 (drainage ditch)	25	1.0×10^{3}	$.3\times10^{3}$

[a] See figure 1 for numbered sampling locations.
[b] The applicable AEC Radiation Protection Standards for uncontrolled areas are as follows:
Polonium-210 in water: 7×10^{3} pCi/liter,
Plutonium-239 in water: 5×10^{4} pCi/liter,
Hydrogen-3 in water: 3×10^{6} pCi/liter.
[c] Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.
[d] Minimum detectable level for hydrogen-3 in water is 0.05×10^{6} pCi/liter.
[e] Minimum detectable level for plutonium-239 in water is 0.09 pCi/liter.

All of the river samples are analyzed for polonium–210. The drainage ditch samples and some of the river samples are analyzed for hydrogen–3 (tritium). The drainage ditch samples are also analyzed for plutonium–239. Average concentrations of hydrogen–3 (tritium), polonium–210, and plutonium–239 are given in table 2 for the first 6 months of 1966.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1965	May 1966
July–December 1965	November 1966

2. Rocky Flats Plant
July–December and annual summary 1966 [3]

Dow Chemical Company
Golden, Colorado

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 2.

[3] Summarized in "Environmental Survey, July-December 1966," The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

To assure properly controlled release of radioactive materials to the environment, periodic samples of air, water, and vegetation are analyzed for gross alpha-particle activity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

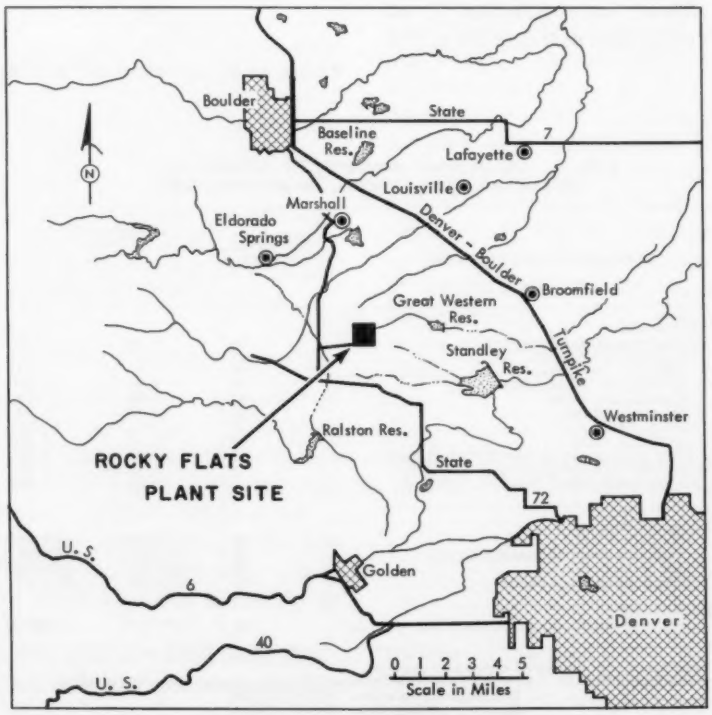

Figure 2. Rocky Flats Plant and environs near Denver, Colorado

Air

Continuous air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha-particle activity shown in table 3 are believed to result from naturally occurring materials. All values are less than the AEC Radiation Protection Standard of 0.04 pCi/m^3 for mixtures of unidentified radionuclides.

Table 3. Long lived gross alpha radioactivity in airborne particulates, RFP environs, January–December 1966

Period	Average radioactivity (pCi/m^3)
January	0.6×10^{-2}
February	$< .6\times10^{-2}$
March	$.7\times10^{-2}$
April	$.9\times10^{-2}$
May	1.0×10^{-2}
June	$< .6\times10^{-2}$
July	$.8\times10^{-2}$
August	$.7\times10^{-2}$
September	$.5\times10^{-2}$
October	2.3×10^{-2}
November	$.9\times10^{-2}$
December	$.4\times10^{-2}$

Water

Regular water samples were obtained once every 2 weeks except during the winter months from four reservoirs in the area of the Rocky Flats Plant. The results of alpha radioactivity analyses performed on these samples are given in table 4. The analytical results for water samples obtained during May and September from outlying streams and lakes are presented in table 5. For comparison purposes, the AEC Radiation Protection Standards for mixtures of unidentified radionuclides in water is 10 pCi/liter.

Table 4. Alpha radioactivity in water, RFP environs, second half and year 1966

Reservoir	Number of samples		Average radioactivity (pCi/liter)	
	Second half 1966	Year 1966	Second half 1966	Year 1966
Great Western	10	18	7.3	5.6
Standley	10	18	7.9	5.0
Baseline	11	19	2.1	1.9
Ralston	8	16	.9	1.6

Table 5. Alpha radioactivity in raw surface waters RFP environs, May and September 1966

Collection period	Number of samples	Average radioactivity (pCi/liter)
May 1966	28	3.5
September 1966	25	2.0

Vegetation

During May 1966, 76 samples of vegetation were collected in the vicinity of Rocky Flats Plant at locations up to 18 miles distant from the plant. Gross alpha radioactivity counts were made on the samples. The results are reported in table 6.

Table 6. Alpha radioactivity in vegetation RFP environs, May 1966

Collection period	Distance from plant	Number of samples	Average radioactivity (pCi/kg dry weight)
May 1966	Less than 3 miles	45	64
	3 to 18 miles	31	64

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	June 1966
January–June 1966	December 1966

SECTION V. TECHNICAL NOTES

Radiological Monitoring of the Native Texas Commercial Oyster

J. J. Stanko and *M. C. Wukasch* [1]

A cooperative agreement was established among the Radiation Surveillance Services group, General Sanitation Services, and laboratory personnel of the Texas State Department of Health, to collect, analyze, and interpret radiation data on the native Texas commercial oyster (*Crassostrea virginica*) (*1*).

The oyster was chosen because of its well-known anatomy and physiology and its economic importance, more than 2,400,000 pounds of meat being harvested during fiscal year 1963 (*2*). The oyster reefs selected for sampling were chosen because of their potential for radioactive contamination, productivity, and accessibility (*3*).

General Sanitation Services, charged with administering the Texas oyster certification program, agreed to collect samples in season for laboratory analyses of radioactive content. The resulting data were compiled and interpreted by the Radiation Surveillance Services group.

Selected Texas certified oyster houses known to harvest from reefs of interest were contacted to obtain their cooperation. Table 1 lists the nearest geographical location, names and coordinates of the sampled reefs, dates of sample collection and analysis, and observed radionuclide activities.

One-quart grab samples of raw oyster meat were obtained from the oyster houses on each of the dates indicated. These were cooled in ice and transported to the State Health Department Laboratory at Austin. Individual quart samples were placed in a 1-liter Marinelli beaker and analyzed for gamma radioactivity, using a 4- by 4-inch NaI (thallium activated) crystal, and a 400-channel analyzer. Samples were then ashed. The ashes were placed in 10-ounce plastic cups and counted again, using the above equipment (*4*, *5*).

Two hundred milligrams of ash from each sample were transferred to a 2½-inch stainless-steel planchets and counted for alpha and beta radioactivity. Beta-particle counting was accomplished using a low-background beta-particle counter; alpha-particle counts were obtained using an internal proportional counter (*4*, *5*). The radioactivity concentrations in picocuries per gram of ash were calculated from the observed counting rates. The method used is described below.

Alpha radioactivity. Sample radioactivity concentrations were calculated using the following formula, which includes the efficiency factor developed for a 200-mg sample (includes self-absorption, geometry, and back scatter):

$$A(\chi) = \frac{C}{f(\chi) \cdot W \cdot 2.22}$$

[1] Mr. Stanko is presently sanitarian, Air Pollution Program, and Mr. Wukasch is chief, Radiation Control Program, Division of Occupational Health and Radiation Control, Texas State Department of Health, Austin, Tex.

Table 1. Sampling locations and analytical results for Texas oyster samples

Sampling location (Texas)	Reef coordinates	Collection date	Analysis date	Gross radioactivity		
				Alpha-particle (pCi/g ash)	Beta-particle (pCi/g ash)	Gamma-ray (cpm/sample)
Sylvan Beach [a]	Unnamed 29° 30′ N 95° 01′ W	11/10/65	12/1/65	10	43	1.0
Seabrook	Todd's Dump 29° 32′ N 94° 54′ W	11/10/65	11/22/65	10	83	NDP
Smith Point	Vintune 29° 33′ N 94° 45′ W	11/8/65	11/29/65	10	55	NDP
Port Lavaca	Gallinipper Point 29° 35′ N 96° 34′ W	11/8/65	11/10/65	10	66	NDP
Matagorda	Unnamed 28° 38′ N 96° 04′ W	12/28/65	12/28/65	18	52	NDP
	Unnamed 28° 38′ N 96° 04′ W	1/11/66	1/17/66	10	106	1.5
Seadrift	Grassy Point 28° 24′ N 96° 47′ W	1/11/66	1/12/66	10	110	1.0
Port Lavaca	Gallinipper Point 28° 35′ N 96° 34′ W	1/11/66	1/12/66	10	165	1.0

[a] Control sample.
NDP, no detectable peaks other than naturally occurring potassium-40.

where $A(\chi)$ = alpha radioactivity concentration (pCi/g),
C = net observed activity (cpm),
W = sample weight (g),
$f(\chi)$ = efficiency factor (cpm/dpm), 0.59,
and 2.22 = conversion factor (dpm/pCi).

Beta radioactivity. Beta radioactivity concentrations were calculated in a similar manner:

$$A(\beta) = \frac{C}{f(\beta) \cdot W \cdot 2.22}$$

where $A(\beta)$ = beta radioactivity concentration (pCi/g),
and $f(\beta)$ = efficiency factor (cpm/dpm), 0.154.

Gamma radioactivity. Printout tapes and corresponding spectrum plots were visually inspected. Radionuclide levels were, in general, limited to varying concentrations of naturally occurring potassium–40. When the potassium–40 concentration was stripped out of the gamma-ray spectrum, it was apparent that the beta-particle activities in all samples could be attributed to this naturally occurring isotope.

Four samples displayed a small peak at an energy of 1.12 MeV, corresponding to the gamma-ray energy of zinc–65 (*6–8*). Table 1 also presents the analytical results obtained during this study.

The monitoring of radioactivity levels in Texas oysters has served a twofold purpose:

1. The establishment of baseline levels from which the extent of possible future contamination can be assessed.

2. The maintenance of a surveillance program in the vicinity of potential sources of contamination for the purpose of detecting and measuring any possible radioactive discharges.

REFERENCES

(*1*) EURE, J. A., and C. R. BARDEN. Radiological Monitoring of the Marine Environment, a Survey of State Activities. Division of Occupational Health and Radiation Control, Texas State Department of Health, Austin, Tex. (June 1963).
(*2*) TEXAS PARKS AND WILDLIFE DEPARTMENT. The Texas Oyster Fishery, Bull No. 40. Austin, Tex.
(*3*) EURE, J. A., and M. C. WUKASCH. The Galveston Environmental Surveillance Program, One Year of Operation Interim Report. Division of Occupational Health and Radiation Control, Texas State Department of Health, Austin, Tex.
(*4*) GOLDIN, A. S., and B. KAHN. Analytical radiochemistry in health physics. Health Physics 11:935-944 (1965).
(*5*) SOUTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Procedures for the Determination of Stable Elements and Radionuclides in Environmental Samples. Editors, C. R. Porter, R. J. Augustine, J. M. Matuszak, Jr., and M. W. Carter, Montgomery, Ala. 36101.
(*6*) MENZIES, R. A. The Uptake of Zinc in Certain Marine Organisms. Unpublished Master of Science Thesis, University of Florida, Gainesville, Fla. (August 1962).
(*7*) CHANNEL, J. K. Uptake, Concentration, and Cycle of Certain Radioisotopes in the Oyster. Unpublished Master of Science in Engineering Thesis. University of Florida, Gainesville, Fla. (January 1960).
(*8*) MURTHY, G. K., A. S. GOLDIN, and J. E. CAMPBELL. Zinc–65 in foods. Science 130:1255-1256.

Strontium-90, Cesium-137, and Polonium-210 in Human Tissues

E. J. Baratta and *E. S. Ferri* [1]

The concentration of strontium–90, cesium–137, and polonium–210 in various human tissues have been measured at the Northeastern Radiological Health Laboratory, Public Health Service, since 1965. The choice of organs for this study was based on the function of the organ, the type of tissue it represented, and whether it was reported that the radionuclides under study tended to concentrate in that organ. Lung was selected because of its major respiratory function and the reported increased levels of polonium–210 in this organ in smokers versus nonsmokers (*1–3*). Liver was chosen because of its major role in metabolism, heart because it represents a visceral muscle tissue, kidney because of its excretory function, and psoas muscle because it represents voluntary or striated muscle which constitutes a major portion of the body mass. Other available tissues were also examined. Although all specimens were from persons who had died of disease, the cause of death could not be considered as a parameter for interpreting the data, because the sample population from any one cause was not large enough.

A detailed discussion of the analytical procedures used and interpretation of the results appear elsewhere (*4*). Table 1 lists the levels of strontium–90, cesium–137, and polonium–210 in the various tissues.

For cesium–137, the International Commission on Radiological Protection (ICRP) model for the "standard man" predicts that for a given body burden the concentration in spleen and liver tissue would be about double that in muscle (*5*). These studies showed the greatest concentration to be in muscle and this was about twice that in the liver and spleen. For strontium–90, it appears that a substantial percentage of the total body burden is also in the muscle. For polonium–210, the ICRP model predicts a maximum concentration in the spleen and a minimum in bone (*5*). This study showed

[1] Mr. Baratta is director and Mrs. Ferri assistant director, Analytical Services, Northeastern Radiological Health Laboratory, National Center for Radiological Health, Public Health Service, Winchester, Mass. 01890.

Table 1. Radionuclide concentrations in adult human tissues

Tissue	Sex	Concentration ±2σ counting error (pCi/100 g wet weight)				
		Strontium-90	Cesium-137	Polonium-210	Polonium-210 (smokers) [a]	Polonium-210 (nonsmokers)
Liver	Male	[b] (6) 0.54±.07	(10) 22±3		(8) 1.3±.03	(2) 1.2 ±.03
	Female	(9) .73±.07	(12) 18±3		(4) 1.2±.04	(8) 1.0 ±.03
Kidney	Male	(7) .88±.10	(10) 19±7		(8) .8±.06	(2) 1.6 ±.04
	Female	(8) .46±.18	(12) 18±8		(4) .8±.09	(8) .6 ±.05
Heart	Male	(5) 1.39±.04	(10) 17±8		(8) .2±.04	(2) .1 ±.03
	Female	(7) .74±.10	(12) 17±9		(4) .4±.08	(8) .3 ±.04
Lung	Male	(2) .47±.04	(4) 16±3		(3) .4±.03	(1) .2 ±.01
	Female	(5) 1.35±.07	(8) 13±3		(3) .4±.02	(5) .3 ±.02
Blood	Male	(2) .25±.25	(10) 22±9		(7) .8±.05	(1) .3 ±.02
	Female	(8) 1.06±.15	(17) 19±10		(4) .2±.06	(8) .4 ±.05
Psoas muscle	Male	(4) 1.87±.33	(5) 40±14		(4) .1±.06	(1) .02±.04
	Female	(3) .19±.30	(5) 52±21		(1) .2±.08	(3) .1 ±.07
Spleen	Male	(3) .4 ±.15	(3) 20±12	(3) 0.4 ±.06		
	Female	(2) .3 ±.20	(2) 20±19	(2) .4 ±.97		
Stomach	Male	(1) .4 ±.09	(1) 25±7	(1) .3 ±.02		
	Female	NA	(1) 15±6	(1) .1 ±.03		
Compact and spongy bone	Male	(4) 10.4 ±.44	(4) 25±25	(4) 3.5 ±.18		
	Female	(8) 6.5 ±.35	(8) 20±25	(8) 2.9 ±.21		
Bone marrow	Male	(4) 6.8 ±.60	(4) 40±53	(4) 2.6 ±.29		
	Female	(4) 7.8 ±.68	(4) 40±60	(4) 2.1 ±.30		
Pancreas	Male	(1) 1.2 ±.49	(1) 55±52	(1) .4 ±.18		
Testes	Male	(2) .5 ±.34	(2) 35±76	(2) 1.56±.30		

[a] Donor smoked one or more packs per day.
[b] Figures in parentheses indicate number of samples analyzed.
NA, no analysis.

that for chronic environmental exposure, the reverse is true—that is, the maximum observed concentration is in the bone, the minimum in the spleen.

Although the data reported are of a limited nature, the differences in the observed values and those predicted by the ICRP model are readily apparent. Much of the biological data used in the ICRP model are based on acute injection exposures in animals. The inadequacies of the model predictions substantiate the call by the ICRP, the National Council on Radiation Protection and Measurements (*6*), the Federal Radiation Council (*7*), and others for greater efforts in measuring the biological parameters underlining the distribution of radionuclides in human beings.

REFERENCES

(*1*) HOLTZMAN, R. B., and F. H. ILCEWICZ. Lead–210 and polonium–210 in tissues of cigarette smokers. Science 153:1259-1260 (September 9, 1966).

(*2*) FERRI, E. S., and E. J. BARATTA. Polonium–210 in tobacco products and human tissues. Radiol Health Data Rep 7:485-488 (September 1966).

(*3*) HILL, C. R. Polonium–210 in man. Nature 208:423-428 (October 30, 1965).

(*4*) BARATTA, E. J., and E. S. FERRI. Radionuclides in selected human tissues. Amer Hyg Assoc J 27:438-443 (September-October 1966).

(*5*) INTERNATIONAL COMMISSION ON RADIATION PROTECTION. Report of ICRP Committee II on permissible dose for internal radiation (1959), with bibliography for biological, mathematical, and physical data. Health Physics 3:1-380 (June 1960).

(*6*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure, NBS Handbook 69:10-11 (June 5, 1959). Available from the Clearinghouse for Federal Scientific and Technical Information. Springfield, Va. 22151.

(*7*) FEDERAL RADIATION COUNCIL. Staff report on background material for the development of radiation protection standards, Report 1:39 (May 13, 1960).

Reported Nuclear Detonations, April 1967

During April 1967, three U.S. Nuclear tests were reported; on April 7, 21 and 27, underground nuclear tests of low yield (less than 20 kilotons TNT equivalent) were conducted by the U.S. Atomic Energy Commission at its Nevada Test Site.

On April 20, 1967, the United States recorded seismic signals which originated from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20 to 200 kilotons TNT equivalent).

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference-card format for the convenience of readers who may wish to clip them for their files.

RADIATION HAZARDS FROM X-RAY DIFFRACTION EQUIPMENT. *J. R. Howley* and *C. Robbins. Radiological Health Data and Reports, Vol 8, May 1967, pp. 245–249.*

Improper or careless use of X-ray diffraction equipment can cause severe burns to the upper extremities of the body of the operator. These burns are slow to heal and can lead to cancer. Cataracts and other opacities can be produced in the eye with a single exposure of 200 roentgens. The use of inadequate survey equipment can lead to a gross underestimate of the hazard. Since serious injury from intense primary beam radiation can occur in a matter of seconds and the hazard from scattered radiation is also significant, the use of film badge monitoring alone can give a false sense of protection. Recommendations are given.

KEY WORDS: cancer, cataracts, film badges, radiation detectors, radiation safety, shielding, X rays, X-ray diffraction equipment.

ORDER BLANK FOR RHD&R

To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

Please enter my subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check ☐ for this subscription. ($5.00 a year; $1.50 additional for foreign mailing.)

Please address RHD&R as follows._____

_____

_____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1965

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Subscription price $5.00 a year, $1.50 additional for foreign mailing.
Price for a single copy of this issue is 50 cents.

May 1967

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi per square meter (mCi/m^2)
MeV	million (mega) electron volts.	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose.	100 ergs per gram

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON D.C. 20201

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.

If you do not desire to continue receiving this publication, please CHECK HERE ☐ tear off this label and return it to the above address. Your name will then be promptly removed from the appropriate mailing list.